The Effectiveness of a Multisensory Writing Program in Improving Cursive Writing Ability in Children with Sensorimotor Difficulties

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ABSTRACT

It is estimated that five to ten percent of children experience sensorimotor difficulties that result in various learning disabilities, among them, inability to output information on paper in the appropriate manner (Ayres, 1985). The relationship between sensorimotor ability and handwriting is well documented in the literature (Freeman, 1917; Townsend, 1951; Nikola-Lisa, 1987). While much of the literature is inconclusive, there are findings to suggest that multisensory handwriting programmes are an effective approach to improving writing ability in these children.

For a number of years, Occupational Therapists have been involved in the remediation of handwriting utilizing, amongst other approaches, multisensory programmes. While subjective assessments of effectiveness have been extremely positive, scientific evaluation has been minimal. If further intervention in this area is to occur, it is essential that the profession be able to justify the existence of such programmes.

The purpose of this study was to examine what effects a multisensory writing program would have on the cursive writing ability of children with sensorimotor difficulties. A single case with multiple baselines across behaviours

design was used, with the behaviours being cursive writing ability of five distinct letter groups. The five groups were taught in random order, one group every two weeks, in a one-hour session. Repeated measurements of writing speed and quality for each letter group were made. This design was repeated over three other cases.

Results of the study yielded statistical significance in trend changes in specific letter groups for all of the children following intervention. One child achieved statistical significance in the overall change in quality, while none of the children achieved overall statistical significance in speed score changes.

Teacher reports and an assessment of written language prior to and following the program suggest that intervention may have had a positive effect on self-confidence in written output, and on the maturity of written expression in some of the cases.

Further research in this field is needed to validate the continual use of multisensory writing programmes by Occupational Therapists working with this specific population and to provide some direction with regards to the integration of multisensory writing programmes within the regular academic remedial programme.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION TO THE PROBLEM

This study is an examination of the effects of a multisensory writing program on the cursive writing ability of children with sensorimotor difficulties.

Problem Background

It has been estimated that five to ten percent of children experience sensorimotor difficulties that result in various learning disabilities, amongst them, inability to output information on paper in the appropriate manner (Ayres, 1985). The relationship between sensorimotor ability and handwriting is well documented in the literature, as will be seen in the following pages.

Written output is an integral part of academic achievement, and its role in the curriculum only increases as the child progresses through the school system. The student who has not mastered the fundamentals of written output, that is, the ability to form the letters automatically without undue planning and organization, will be ill-prepared to meet the demands of the higher grades. Tests and assignments will be completed slowly, and effort spent on the mechanics of the task will result in decreased attention to the content

required. In addition, poor performance will only serve to lower self-esteem and will result in ongoing frustration (Kephart, 1960).

Many school systems, anticipating difficulties with written output in higher grades for certain students, provide equipment such as typewriters and computers. While this serves to make the task easier for the student, it is done at great cost, and often for students who, with some remediation of writing ability, would have been able to perform satisfactorily in terms of written output within the school setting.

Children are traditionally taught the formation of letters needed for cursive writing in Grade Three. The vast majority of these children experience no difficulty mastering the production of these letters and, within a year, are able to form them automatically and smoothly. Children with sensorimotor difficulties, however, lack the feedback from sensory systems necessary for visualizing the formation of these "engrams" or "mental maps" (Ayres,1985). They cannot generalize learning from one engram to another and thus require significant additional practice and "overlearning". Unfortunately, the school curriculum does not allow for the extra time needed for this experience.

While much of the literature is inconclusive, there is considerable evidence to support the effectiveness of multisensory writing programmes in improving cursive writing ability in both the "normal" population, and with children with sensorimotor difficulties.

Statement of the Problem Situation

This study examined what effects, if any, a multisensory writing program has on the speed and quality of cursive writing of children with sensorimotor difficulties, who are enrolled in the junior grades in the Hamilton-Wentworth school system.

Statement of Hypotheses

The first hypothesis is that, following each of five sessions of a multisensory writing program, four children with sensorimotor difficulties exhibit a statistically significant improvement in quality scores on the letter group learned during the preceding session.

The second hypothesis is that, following each of five sessions of a multisensory writing program, four children with sensorimotor difficulties exhibit a statistically

significant improvement in speed scores on the letter group learned during the preceding session.

Importance of the Study

While written work represents only one of the many concerns of children with sensorimotor difficulties, most of the attention has focused on this particular academic skill, probably because of its emphasis in the curriculum. Thus, a successful multisensory writing programme would be of considerable value. It would provide immediate benefit to the child in terms of decreased frustration, increased self-esteem and potential for improved writing skills in school. Potential costs in terms of possible equipment or assistance needed for written output would also be curtailed. Furthermore, the results of such a study could be used to provide information needed for the integration of multisensory writing programmes within regular academic remedial programmes, where needed.

For a number of years, Occupational Therapists have been involved in the remediation of handwriting utilizing, amongst other approaches, multisensory programmes. While subjective assessments of effectiveness have been extremely positive, scientific evaluation has been minimal. If further

intervention in this area is to continue, it is essential that the profession be able to justify the existence of such programmes.

Definition of Terms

Children with sensorimotor difficulties, for the purpose of this study, are those children who have been found to have difficulty with the ability to process sensory information adequately, and are thus unable to output motoric responses appropriately.

A multisensory writing program is defined as a treatment program consisting of five one-hour sessions, aimed at improving the formation of written letters through the use of visual, tactile and kinesthetic activities.

Cursive writing ability is the ability to form letters on paper with the strokes of successive letters joined and the angles rounded.

For the purpose of this study, effectiveness of a multisensory writing program is indicated by a statistically significant decrease on quality and time scores.

An intervention is a treatment session in which one letter group is targeted for remediation.

A trial is one session in which quality and speed measures of cursive writing ability are taken. Six trials, between two interventions, will constitute a series.

Limitations of the Study

1. The program implemented for the purpose of this study attempts to remediate only two concepts, namely speed and quality of cursive writing ability.

2. The study pertains only to children with sensorimotor difficulties.

3. The conclusions drawn from this study are applicable specifically to children in the junior grades in the Hamilton-Wentworth school system. The population is taken from here and therefore cannot be generalized.

Outline of Remainder of the Document

Over the next several pages, the literature relating to handwriting, sensorimotor ability, and multisensory writing programmes is reviewed. The review reinforces the relationship which exists between handwriting and sensorimotor ability, and also focuses on the effectiveness of multisensory writing programmes.

The third chapter examines the research design utilized for the purpose of this study and the rationale for choosing this particular design. The subject selection is discussed, and the procedures used in the intervention and data gathering is outlined. Lastly, the method used in the analysis of the results is discussed.

In the final two chapters, the results of this study are documented and discussed, with reference to limitations within the design. Finally, conclusions are drawn with recommendations for future research in this area.

CHAPTER II: REVIEW OF THE LITERATURE

Introduction

It seemed appropriate to begin a review of the related literature with an exploration of material supporting the close relationship between sensorimotor ability and handwriting. The second stage of the review emphasized the literature that has examined the efficacy of multisensory approaches in the teaching of handwriting.

In order to "put all the pieces together", the final area of review involved the exploration of those studies that examined the specific remediation of sensorimotor handwriting difficulties, utilizing multisensory approaches.

Sensorimotor Ability and Handwriting

One of the first individuals to draw attention to the importance of sensorimotor development was the noted Swiss psychologist, Jean Piaget. After observing three children for a number of years, he formulated a theory of cognitive development, which had as its foundation a sensorimotor stage lasting through the first two years of life, during

which time the child responded to and learned about his environment directly through his sensations and motor responses (Piaget, 1952). Since that time, others have extensively studied this particular aspect of development and ability (e.g., Kephart, 1960; Cratty, 1979; Ayres, 1979).

It is generally accepted that handwriting is not an innate ability, and that the child must develop this particular skill through experience and practice. As early as 1917, Freeman, in discussing the nature of learning in handwriting, termed it sensorimotor learning. He noted that sensations are necessary to develop the skill and for proper control of the movements. He further described handwriting as a type of learning in which movements which are already familiar are selected and organized into new patterns of movements. Lastly, he stressed the importance of the development of a clear perceptual image to serve as a model in the motor formation of the letters.

Townsend (1951) discussed the relationship between visual perception and motor skills needed in the reproduction of any form, noting that Bender (1938, cited in Townsend, 1951) had already emphasized the constant interplay between motor and sensory features in this particular task. Townsend's

study of 287 New York school children aged six years one month to nine years three months examined the relationship between copying ability and both visual perception and motor ability. His results found that there was a significant correlation with both components, and that the correlation with visual perception was higher. He postulated that dysfunction in either area would result in inadequacy in copying skills and that, even if adequate motor ability were present, it could not be expressed without adequate visual perceptual ability; that is, dysfunction within the visual perceptual system would result in misdirection of motor skills with reference to copying.

A dearth of literature in recent years pertaining to sensorimotor ability and handwriting suggests that earlier literature supporting a correlation between the two was felt to be conclusive. One recent study by Nikola-Lisa (1987) examined motor, perceptual-motor, and cognitive ability in two hundred ninety-seven second grade students attending three different Montana school systems, to determine what factors are responsible for discriminating between above-average and below-average handwriting legibility. The results of his study supported the hypothesis and previous

literature that perceptual and perceptual-motor ability are the most important components.

Multisensory Approaches to the Teaching of Handwriting

Research in the teaching of handwriting using a multisensory approach began to develop approximately two decades ago. In 1967, Birch and Lefford stimulated interest by proposing a model in which voluntary motor control is a function of visual perceptual ability and integration of visual, tactile and kinesthetic senses. To test their model,they studied the ability of children, ages five to eleven years, to copy shapes. The shapes were presented to the children under six conditions of various stimulus support ranging from a tracing task (maximum stimulus support) to freehand drawing (minimum stimulus support). The results indicated that while the older children were comfortable with all levels of stimulus support, the younger children performed much better with the tracing tasks, providing considerable kinesthetic input. The implications of the study were that young children should be taught handwriting through tracing with gradual withdrawal of stimulus support.

Furner (1969, 1969, 1970), in a series of articles, described extensively an instructional approach which

attempted to coordinate handwriting instruction with children's perceptual development. She suggested that, since handwriting had been found to be a type of perceptual-motor learning, instruction should address this perceptual development. Her approach, which consisted of the visual presentation of groups of letters (visual stimulation), the observation of the formation of these letters (kinesthetic stimulation) with verbal description of the formation (auditory stimulation), was taught to Grade One, Two and Three classes in four midwestern schools over a three year period. Seven midwestern schools, utilizing regular commercial programmes, acted as the control group. Speed and quality of handwriting were assessed twice a year for the duration of the study. For all grade levels, the experimental group performed significantly better than the control group in terms of quality. There was no overall significant difference in speed between the two groups, although the experimental group was found to be slightly faster at the end of each year. On the basis of her findings, Furner recommended that children should be taught handwriting through a multisensory approach "since people appear to respond best to multiple modes" (p. 69).

Hirsch and Niedermeyer (1973) studied the effectiveness of tracing versus copying practice, with training in discrimination between letters, on the handwriting performance of fifty kindergarten children. They randomly assigned the children to four treatment groups: 1) copying only, 2) faded tracing only, 3) copying with discrimination training, and 4) tracing with discrimination training. While post-treatment testing demonstrated significant improvement in all groups, those receiving copying exercises performed significantly better than those receiving tracing exercises with faded visual prompts. Letter discrimination training had no effect on handwriting ability. In noting the discrepancy between their results and those of Birch and Lefford, Hirsch and Niedermeyer suggested that the types of visual prompts may have been a factor, and that these prompts "must be chosen carefully in order for them to have a positive effect on motor performance" (p. 85).

Askov (1975) also studied the effectiveness of copying versus tracing on handwriting ability of children, and her results corroborated the findings of Hirsch and Niedermeyer. However, while she changed the types of tracing prompts to "eliminate the difficulties encountered in the earlier study", she made no mention, in her publication, as to what

these changes entailed. In addition, certain factors such as the use of a "responsible" student in the implementation of the program served to lessen the credibility of the study findings.

In a study of twenty-four eight year olds identified as above- and below-average handwriters and randomly selected from three public schools, Sovik (1976) found that verbal instruction in conjunction with demonstration, significantly improved the subject's copying performance. Students were given three treatments, the first consisting of copying letterlike figures freehand, the second of attending to the instructor's hand while the figure was being drawn and then responding by copying the figure, and the third, listening to a detailed explanation while the instructor was drawing the figure and then responding by copying the figure. The time spent on the series of treatments ranged from fifteen to twenty minutes. Ratings, designed for the purpose of the study, were given to the subjects' written products. While Sovik did not make allowances for the improvement that may have taken place merely as a result of practice from one treatment to the next, certainly the study indicated that this area merited further research, especially with poor writers.

In a series of further studies, Sovik (1980,1980,1981) examined various types of handwriting instruction and training, theorizing that appropriate instruction could improve a child's perceptual-motor skills and sensory feedback system. In the first study, he looked at the learning effects of repeated treatments in copying and different tracing/tracking behaviours of 32 children, ages seven and ten years. The results showed a learning effect in copying for the younger subjects, in some tracing behaviour for the older subjects, and in tracking for all subjects.

In the second study, Sovik addressed the theory that children will receive more detailed sensory feedback from a dynamic than from a static model display in tracing/copying tasks. Sixteen 7 and 10 year old students, randomly selected from the population of children at a public school, took part in a study organized as a two-way design. The results verified the hypotheses that 1) presentation of dynamic designs, in general, will give higher accuracy scores in tracing performances of 7 and 10 year old subjects compared with a presentation of static designs, and 2) the dynamic display effect will be greater at the 7-year age level than at the 10-year age level.

In his last study, Sovik investigated whether an experimental program of systematic and individualized training in copying, tracing, and tracking could improve such performance of third graders compared with corresponding performances of third graders receiving no systematic training in the same skills. On the basis of previous research, he hypothesized that a feedback-oriented, individualized training program in tracing performance (H1), tracking performance (H2), and copying performance (H3) would increase significantly the performance of younger children. He also hypothesized, based on the relationship which seems to exist among these various skills, that systematic , individualized training in copying, tracing, and tracking would result in significant transfer of learning with regard to handwriting (H4). The analyses carried out on each of the individual perceptual-motor skills showed that the children in the experimental group surpassed those in the control group for each of the skills, but that the findings were only significant for tracking and copying. The experimental children also scored significantly higher on a precision writing test supporting the fourth and last hypothesis.

Finally, Hayes (1982) examined the effects of various levels of perceptual prompts, namely copying practice with no prompting, visual demonstration with copying practice, visual and verbal demonstration with copying practice, and visual and verbal demonstration plus subject verbalization with copying practice. Forty-five six-year-old kindergarten children and 45 nine-year-old third grade children enrolled in a rural primary school and randomly selected from that population, were then randomly assigned to one of the four "prompt" groups or a fifth control group. Results of testing, following a twenty minute training session, revealed that the greater the number of perceptual prompts during training, the greater the accuracy in reproducing model forms.

Multisensory Approaches to the Remediation of Handwriting in Children with Sensorimotor Difficulties

Very little research has been published with regards to multisensory remediation of handwriting in children with sensorimotor difficulties, possibly because the diagnosis of sensorimotor dysfunction tends to fall within the realm of health, while remediation of handwriting remains a function of education.

Fauke and Powers (1973) conducted a study to determine the effectiveness of a behaviour modification procedure combined with a multisensory approach, to improve handwriting skills of a six year old boy exhibiting difficulties in the printing of letters. In choosing a multisensory approach, the experimenters noted the work of Green (1967), Fernald (1943), and Shea (1956), (all cited in Fauke and Powers, 1973) who stressed a kinesthetic approach in the teaching of handwriting. The researchers' own study was a single subject experimental design, ABAB, extending over a three-week, fourteen-session experimental period, in a one-to-one setting. The program consisted of labelling letters verbally upon a visual presentation, tracing over letters on worksheets with finger, pencil and magic marker, tracing over letters made of yarn, copying letters beside and below a given model, observing the instructor modelling the correct formation while verbalizing simultaneously, and printing letters on lined, then unlined paper. Candy was initially paired with praise, then removed as the experiment progressed.

While the results of the study supported the data in the literature emphasizing a multisensory approach to teaching handwriting, it was very difficult to determine to what

extent improvement was dependent on that approach and how much it was influenced by behaviour modification procedures. The researchers, themselves, acknowledged this difficulty and suggested that further research was needed to study which, if either, had the stronger effect.

Robin, Armel and O'Leary (1975) compared the effectiveness of self-instruction with direct training and no training on the printing of thirty kindergarteners having deficient writing skills as determined by a handwriting test. The subjects, who were enrolled in one elementary school, were randomly assigned to one of three groups: self-instructed, direct training, or no treatment. During the experiment, subjects in the two treatment groups received training three times a week over seven weeks. Children in the no treatment groups received pre- and post-tests only. Children in the direct-training group received social reinforcement and feedback, which consisted of comparing the child's letters to models. The self-instructed group received the social reinforcement and feedback in addition to self-instructional training. This latter consisted of the modelling of correct letter formation with accompanying verbalization of the correct action. Later in the process, the student verbalized with the instructor, then simultaneously copied and

verbalized. Finally, subjects copied letters and whispered self-instructions.

Statistical analysis of pre- and post-test results showed that the self-instructed group performed significantly better than the direct training group, and that both groups were significantly better than the no treatment group. While it should be noted that the control group received no intervention and that the effect of attention on the other two groups could certainly have been a factor, this could not explain the difference between the two experimental groups. One last point with regards to Robin's study is that while the program was described as a self-instructional program, it was, in essence, a multisensory program consisting of visual, auditory, and kinesthetic input.

Graham (1983) studied the effectiveness of a self-instructional procedure in improving and maintaining the letter formation skills of learning disabled students with writing deficiencies. Three students who met the following criteria of a) identified learning disabled, b) having identified difficulties in the formation of letters, and c) having received less than a specific score on an administered handwriting scale were selected. A multiple-baseline-across-subjects design was used. The study

consisted of three phases, namely baseline, the teaching of the letter "g" through a multisensory approach, and finally, the teaching of the letter "a" through a multisensory approach. The training letters plus four generalization letters (p,q,o,e) were written daily, and scored according to a point-rating scale. While the author noted that the treatment procedure was moderately effective, it should be noted that no mention was made of the significance of the improvement.

Finally, in 1984, Sovik repeated his 1981 study in which he investigated whether an experimental program of systematic and individualized training in copying, tracing, and tracking would improve such performances of third graders. However, for the more recent study, he elected to examine dysgraphic instead of normal third-grade writers, hypothesizing that the effects would be similar. On post-testing, the experimental group performed significantly better than the control group in terms of accuracy. In discussion, Sovik offered the opinion that traditional handwriting instruction in most schools does not offer children disposed towards writing difficulties individualized and adapted instruction that will meet their needs.

This last section has provided an overview of the very limited amount of literature which exists pertaining to the remediation of handwriting in children with sensorimotor difficulties utilizing a multisensory approach. As the boundaries of the health and education disciplines grow "fuzzier" with regards to certain aspects of child's development, it is expected that more research will be conducted in this area.

Summary

This chapter has given the reader an overview of the related literature, which provided a foundation for the development of this study. While the literature supports the strong relationship between handwriting skill and sensorimotor ability, studies pertaining to the effectiveness of multisensory writing programmes in improving this particular skill in both the "normal" population and in children with sensorimotor difficulties are still somewhat inconclusive.

CHAPTER III: METHODOLOGY

Overview

An experimental study was conducted by the investigator using a single case with multiple baselines across behaviours design, with the behaviours being cursive writing ability of five distinct letter groups. Repeated measurements of writing speed and quality were made by an independent evaluator, and the study was replicated over three other cases. The sample for the study was taken from children who met the inclusion criteria and whose parents had given consent to their participation in the study.

The treatment program consisted of five one-hour sessions, conducted at the same time every other week by the investigator. Each of the five sessions focused on remediation of a targeted group of letters. Two outcome measures were selected for the study, speed and quality of cursive writing, and a total of thirty-six measurements were taken for each letter group.

The classroom teacher of each participating child was required to complete a questionnaire prior to the start of

the study, and again at the end of the study, in which he or she was asked to rate the child's cursive writing ability in terms of 1) neatness, and 2) speed. In addition, prior to the study and following completion, each child was administered the Handwriting, Vocabulary and Thematic Maturity components of the Test of Written Language (TOWL). These were scored by a blind evaluator at the end of the study.

The data was analyzed using both visual and statistical analysis. Data was collected from each trial and graphed against time for visual analysis. A test of ranks was performed for the purpose of statistical analysis.

This provides a brief overview of the procedures used in conducting this study. A more comprehensive description of the methodology is outlined in this chapter.

Research Design

For the purpose of this study, a single case with multiple baselines across behaviours design was used, with the behaviours being cursive writing ability of five distinct letter groups. The five letter groups were taught in random order. Repeated measurements of writing speed and quality

for each letter group were made by an independent evaluator who was blind to the order in which the letter groups were being presented. This design was replicated over three other cases (four in total), with the exception of the order of presentation of letter groups which was randomized for each case.

Since large numbers of children who met the inclusion criteria for the study were not readily available, the single case design was selected over a more traditional randomized design. This eliminated the need for "controls" who matched for such things as age, grade level, degree of sensorimotor difficulty, and socioeconomic status. The single case design offered an additional advantage in terms of the relatively minimal cost and time requirements.

A disadvantage of the single case design is the inability to generalize the results to a larger group. Replication over other single cases, however, allows one to observe consistent patterns, and thus draw some conclusions about the effectiveness of the intervention (Barlow & Hersen, 1985).

A multiple baselines-across-behaviours design was advantageous for this particular study in that an

intervention, namely a multisensory cursive writing program, was being applied to improve specifically targeted behaviours, that is, writing performance on five distinct letter groups. While interdependence between behaviours is often a problem with this particular design (Ottenbacher, 1986), the patterns of formation of the different letter groups are distinct, and learning is not generalized from one group to another. This is particularly true in the case of children with sensorimotor difficulties who, as mentioned previously, need significant practice for the learning of each engram, and cannot generalize learning from one engram to another.

Selection of Subjects

The entire sample for this study was selected from children who met the inclusion criteria, who had given consent to participation (Appendix B) and whose parents had given consent to participation (Appendix A). A series of four single case experiments was carried out.

The children selected must have been referred to the Occupational Therapy Department at Chedoke-McMaster Hospitals, a large teaching hospital in southern Ontario, for assessment. They subsequently must have been identified

as having sensorimotor difficulties and accompanying writing problems. The researcher was not involved in this assessment process in any way.

The children must also have been enrolled in grades four, *five or six in the Hamilton-Wentworth school system. While it was necessary that there be prior exposure to cursive writing in the classroom, evidence in the literature has supported the idea that younger children are more responsive to intervention in terms of writing remediation, hence the exclusion of children beyond grade six.

Children who were receiving concurrent treatment, including drug therapy, that might have contaminated the results of the study, were excluded. Written language difficulties that might have seriously interfered with the child's ability to demonstrate improvement on the speed and quality of written words were also a criterion for exclusion from the study. (A Speech and Language Pathologist screened initial written samples of all children). Lastly, those children with physical disabilities or identified cognitive impairments were not included in the study.

The four children who were eventually selected were all boys, ranging in age from nine to eleven years. One of the

students was in a self-contained class for children with specific learning disabilities, while the other three were in regular classroom settings, receiving resource help.

Intervention

The treatment programme consisted of five one-hour sessions conducted at the same time every other week. The time of day was also consistent. The sessions were held at the child's school during the academic year. In the event of absenteeism, the treatment session was rescheduled for the child's second day back at school, and if not possible, the next available day.

Each of the five sessions focused on remediation of a targeted group of letters, with the breakdown of groups as follows:

Group 1 - c, a, d, g, q, o

Group 2 - m, n, v, x, y, z

Group 3 - l, t, u, w, j

Group 4 - e, l, h, k, f, b

Group 5 - p, r, s

Four of the groups consisted of letters which follow a familiar pattern of formation in cursive writing. The fifth

group consisted of three letters which do not fit a consistent pattern.

All sessions, which were conducted by the researcher, consisted of a series of activities and exercises that followed a specific format. These exercises are outlined in Appendix C with accompanying rationale, in the order in which they were presented to the child. Letters from the first group have been used as an example for the purpose of clarity.

The child was required to complete fifteen minutes of "homework" each evening. This consisted of writing practice, specifically with the letters targeted during the previous session. The child brought his/her completed homework to the following session, and it was collected by the researcher at the end of the study. Homework compliance was subsequently examined in relation to measurement performance.

Data Collection

Two outcome measures were selected for this study, speed and quality of cursive writing. Six baseline measurements were made prior to the introduction of the first group of letters, which represented the minimum number of trials that were required to demonstrate a relationship between intervention and behaviour (Ottenbacher, 1986). Subsequent to this, six measurements were taken, followed by the introduction of another group of letters. This pattern was repeated until the last group of letters had been taught. Six final measurements followed this.

During each trial, the child was given a list of ten printed combinations of letters from each group, the order of presentation of groups being randomized (see appendix D). The combination of letters did not exceed four, and the child was encouraged to copy down each entire combination without breaking, using verbal rehearsal strategies. While it would have been preferable to have the child copy words rather than combinations of letters, the lack of vowels in some letter groups made this impossible. Printed letters were presented rather than written ones so that the child

did not copy the formation from the model. Combinations of letters were varied from one trial to another.

To measure speed of writing, the evaluator recorded the length of time that the child was actually forming the letters. The stopwatch was started at the beginning of the first combination, and stopped when that combination had been completed. It did not start again until the child placed his/her pencil on the paper for the second combination. The total time that had elapsed on the stopwatch, in seconds, at the end of the last combination was recorded.

To measure quality of writing, the evaluator followed a set of criteria outlined by the researcher, awarding points to errors in form. A letter incorrectly formed, for example the letter "a" produced in a clockwise instead of a counterclockwise direction, was awarded two points since it was felt to represent a significant fault in form. Other errors such as a letter being started in the wrong place, finished in the wrong place, or not closed properly, received one point. Height of letters including ascenders and descenders was measured using a gauge, with anything outside an eight-inch margin receiving one point. Errors in formation were to be observed during the actual trial. All

other errors could be evaluated by looking at the completed work and, thus, were scored following the trial. The total number of points received was recorded.

At the end of each trial, speed and quality scores had been calculated for each of the five groups of letters (see Appendix E).

Prior to the start of the study, each of the four evaluators was instructed verbally in the scoring procedure by the researcher. At the end of the instruction session, a simulated trial was carried out in which the researcher produced on paper combinations of letters with common errors in formation. The evaluator was required to score the researcher for both quality and speed, as he/she would do during the real trial. Inconsistencies in scoring were subsequently discussed, with further simulated trials as necessary. The evaluator was provided with a written copy of the instructions (see Appendix F), in addition to models of the correct formation of each of the 26 letters. It is important to note that since single-case designs were being carried out, it was not necessary for the four evaluators (one for each of the four children) to score similarly, but only that each of the evaluators remain consistent within her own scoring system.

Additional Instrumentation

Prior to the start of the study, the classroom teacher of each participating child was required to fill out a questionnaire in which he/she was asked to rate the child's cursive writing ability in terms of: 1) neatness and legibility, and 2) ability to keep up with the rest of the class. At the end of the study, the teachers were, again, asked to complete a questionnaire, this time to rate improvement in cursive writing ability in the above areas (see Appendix G). The use of such a questionnaire enabled the researcher to determine whether changes in outcome measures during the study equated with changes in functional writing ability in the classroom.

Prior to the completion of the first baseline measurement, and following the final trial, each child was administered the Handwriting component of the TOWL. While no statistically significant change could be determined by comparison of the pre- and post-test scores for each child, a subjective assessment could, again, be made of the relationship between changes in outcome measures and changes in functional writing ability. The TOWL had been selected because it is an assessment tool that is easy to administer and provides a global picture of a child's writing ability

in terms of legibility. On the Handwriting component, the child is asked to study three pictures for five minutes, then write a story about the pictures. The writing process is not timed; however, it is usually done in approximately fifteen minutes. The child is asked to compose a piece that is at least fifty words in length. In scoring the test, the evaluator matches the child's writing to graded examples of cursive writing provided with the assessment tool, and awards a score of zero to ten.

Thematic maturity and vocabulary, two additional components of the TOWL, were also assessed using the same picture story. To score vocabulary, the evaluator awards a point to all words in the story that exceed six letters. In scoring thematic maturity, the evaluator awards a point to each of 20 criteria that have been met. These criteria address the content of the story itself. While vocabulary and thematic maturity address the language component of written output rather than the mechanics, the use of these results could help to determine if written expression matured when the task of handwriting itself became easier.

Following the final administration of the TOWL, the pre- and post-test samples for all four subjects were numbered, then

scored by a blind evaluator, a Speech Language Pathologist, who rated all eight samples together.

Statistical Analysis

The data from each subject were analyzed individually, using techniques of both visual and statistical analysis, and then trends across cases were examined to see if similarities existed.

Data collected from each trial, which included speed and quality of writing across target behaviours, were graphed against time for visual analysis. trend lines were drawn for each graph to determine trend changes, and Bloom's table of probability was used to determine the significance of the changes (Ottenbacher, 1986). (The procedure used in computing a trend line is outlined in Appendix H).

A test of ranks (Rn) was performed for the purpose of statistical analysis. Performance means (X) were established for each series of six trials, for each letter group, in both outcome measures. The mean score of a letter group in the series immediately following its intervention, and those letter groups not having received intervention yet, were ranked according to performance level. Those letter groups

which had already received intervention were not included in the ranking. The ranks were summed for all letter groups to determine statistical significance (Barlow & Hersen, 1985).

Response levels across letter groups were widely discrepant during the baseline, that is, the degree of difficulty that each child had in producing each of the letter groups varied. As a result, a data transformation (Barlow & Hersen, 1985) that is shown in more detail in Appendix I, was used to reduce variability:

$$\frac{B1-A1}{A1}$$

where B1 was the mean performance level for letter Group 1 in the trial series immediately following the treatment intervention, and A1 was the mean performance across all baseline days (the initial series) for the same letter group.

Methodological Assumptions

It is assumed that all children who took part in the study had been accurately identified at Chedoke-McMaster Hospitals as having sensorimotor difficulties. It is also assumed that

the evaluators were consistent from session to session in their scoring, following verbal and written instruction.

Limitations

Although evaluators were asked to administer the trials at a consistent time, it was felt that, with demands of conflicting schedules, this would not always be possible. Consequently, performance levels might have varied partially as a result of fluctuating levels of alertness.

Due to the time restraints, it was necessary to schedule treatment sessions and trials around March break for two of the children. This resulted in an unintentional one-week "washout" period.

Efforts were made to prevent the "learning" of the combinations of letters by providing the child with different combinations for the first six trials, then repeating these combinations for the next series of six trials, and each subsequent series. However, a child with a strong memory might have retained some information, thus making subsequent trials easier.

Restatement of the Problem Situation

This study examined the effects of a multisensory writing program on the speed and quality of cursive writing of children with sensorimotor difficulties, enrolled in the junior grades in the Hamilton-Wentworth school system.

CHAPTER IV: RESULTS

Findings Related to Original Hypotheses

The first hypothesis stated in the initial chapter was that, following each of five sessions of a multisensory writing programme, four children with sensorimotor difficulties exhibit a statistically significant decrease in quality scores on the letter group learned during the preceding session.

The second hypothesis stated that, following each of five sessons of a multisensory writing programme, four children with sensorimotor difficulties exhibit a statistically significant decrease in speed scores on the letter group learned during the preceding session.

Child A

Visual Analysis

Visual analysis of quality and speed of all letter groups for child A indicated a great deal of variance in improvement from the baseline to intervention phase.

While the quality scores for letter Group 1 (Figure 1) following intervention were lower than those during the

baseline phase, all but one fell above the trend line, and thus the change in trend was not significant at the $P<.05$ level, as determined by Bloom's probability table (Ottenbacher, 1986).

The quality scores for letter Group 2 (Figure 2) demonstrated considerable variation during the baseline phase with a trend towards increase in scores. There was an immediate decrease in scores following intervention, with all data points throughout this phase remaining below the trend line. The change in trend was statistically significant at the $P<.05$ level.

The quality scores for letter Group 3 (Figure 3) also varied considerably throughout the baseline phase. Scores following intervention were more consistent, with all data points, again falling below the trend line. There was statistical significance at the $P<.05$ level.

The quality scores for letter Group 4 decreased throughout the baseline phase, so that, at the time of intervention, point scores were already low (Figure 4). While post-intervention scores remained consistently low due to the spontaneous improvement prior to the intervention, all data points following intervention were above the trend

line. The change in trend was therefore not statistically significant at the $P<.05$ level.

Quality scores for letter Group 5 (Figure 5) increased throughout the baseline phase with a sharp decline immediately following intervention. While scores in the post-intervention phase were similar to those in the early trials of the baseline phase, the increasing trend line resulted in all post-intervention data points being below it. The change was statistically significant at the $P<.05$ level.

The speed scores for letter Group 1 (Figure 6) remained relatively unchanged from the baseline phase to the post-intervention phase, with only a marginal lowering of scores during the final trials. While one of the data points following intervention fell below the trend line, ten of the twelve post-intervention data points were required to be under the line in order for statistical significance at the $P<.05$ level to occur (Ottenbacher, 1986).

Speed scores for letter Group 2 (Figure 7) decreased dramatically within the short baseline phase, creating a trend line which reached the x-axis (0 point score) almost immediately. As a result, while there was an evident

decrease in scores subsequent to the intervention, statistical significance at the $P<.05$ level was not achievable.

Speed scores for letter Group 3 (Figure 8) showed a pattern similar to, though not as dramatic as, that of letter Group 2. Scores decreased during the baseline period with the result that the trend line reached the x-axis prior to the end of the trials, making statistical significance unmanageable.

Speed scores for letter Group 4 (Figure 9) decreased gradually throughout the baseline period, with the decrease continuing into the post-intervention phase. While four of the six data points following intervention lay below the celeration line, Bloom's probability table requires that all six of six data points lie below the line in order for the change in trend to be statistically significant.

Speed scores for letter Group 5 (Figure 10) followed a pattern similar to that of letter Group 2. There was a rapid decrease in scores during the baseline phase with a resulting trend line that achieved the x-axis immediately following the intervention. There was no statistical significance at the $P<.05$ level.

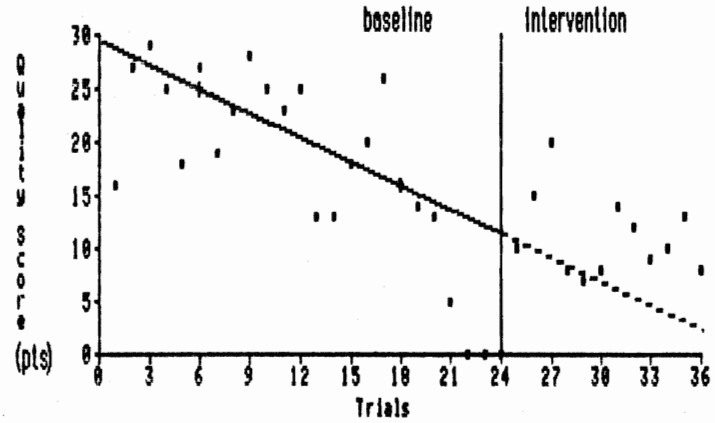

Figure 1. Quality scores of letter group 1 over time: child A

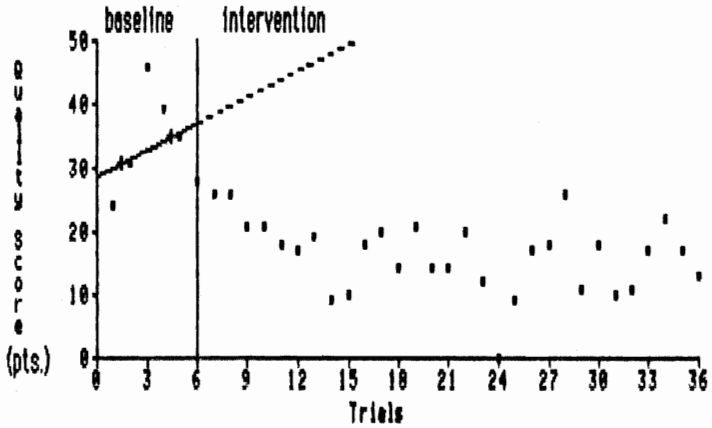

Figure 2. Quality scores of letter group 2 over time: child A

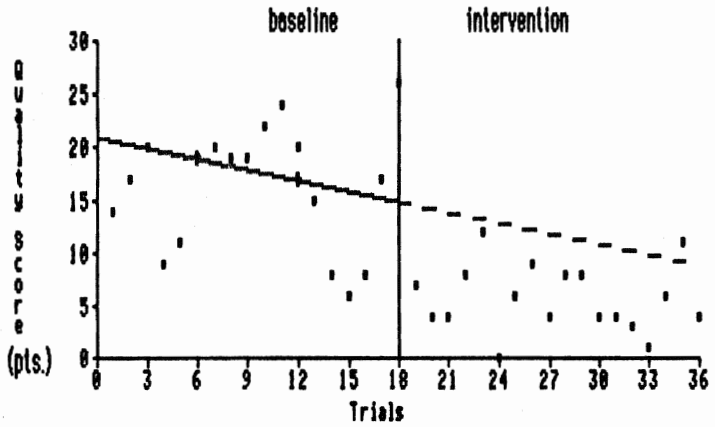

Figure 3. Quality scores of letter group 3 over time: child A

Figure 4. Quality scores of letter group 4 over time: child A

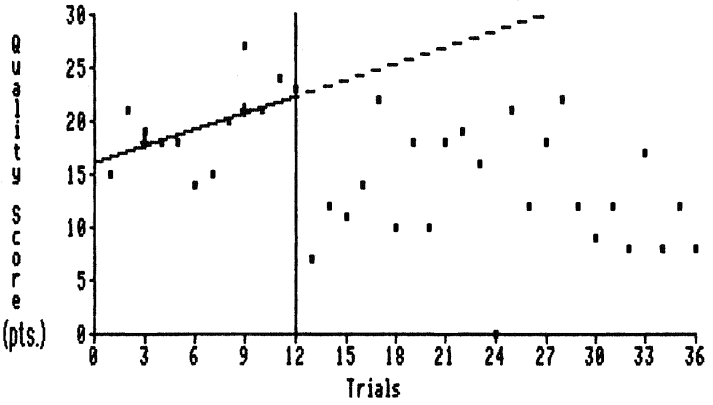

Figure 5. Quality scores of letter group 5 over time: child A

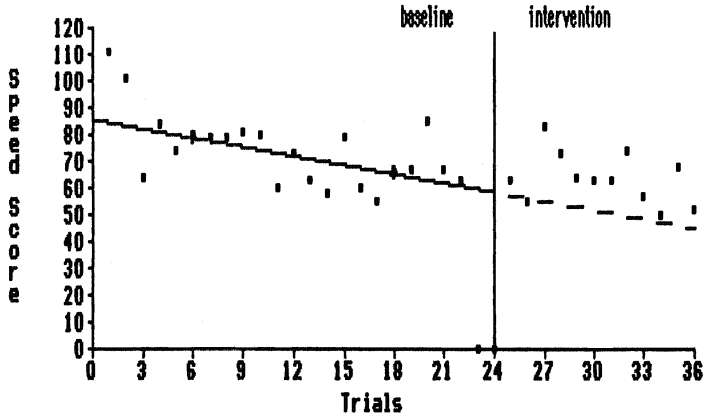

Figure 6. Speed scores of letter group 1 over time: child A

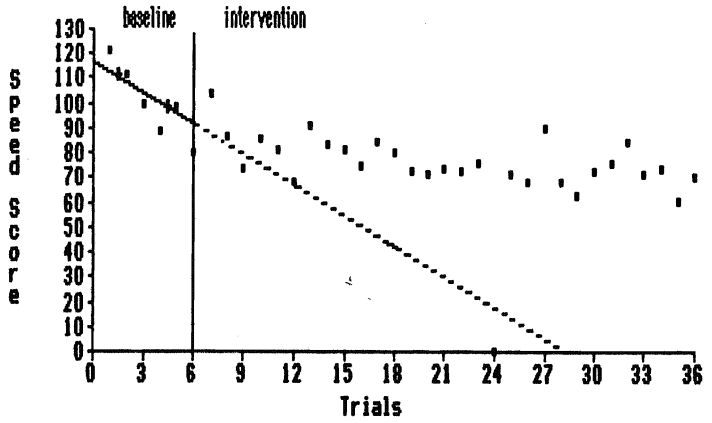

Figure 7. Speed scores of letter group 2 over time: child A

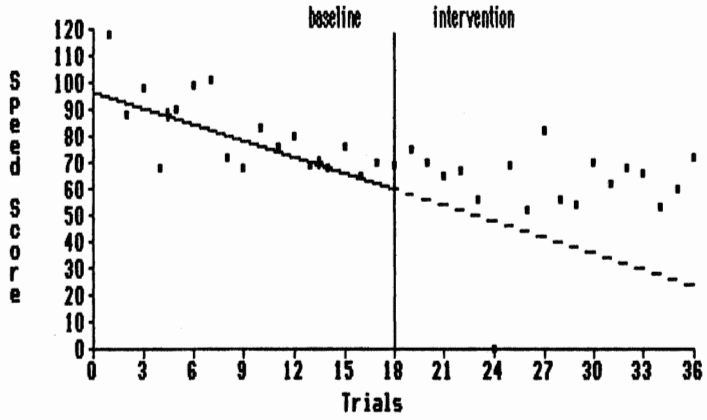

Figure 8. Speed scores of letter group 3 over time: child A

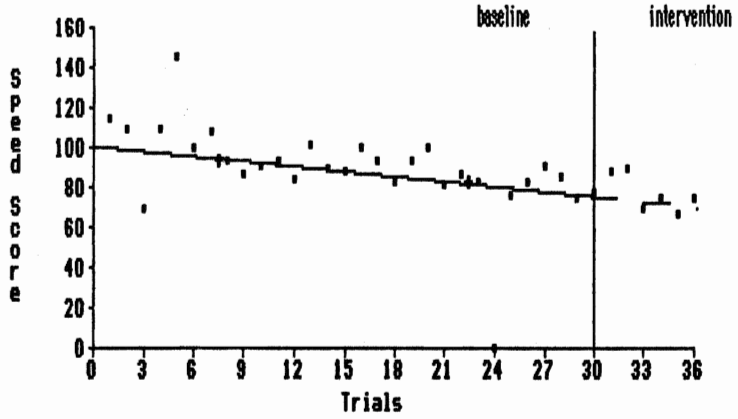

Figure 9. Speed scores of letter group 4 over time: child A

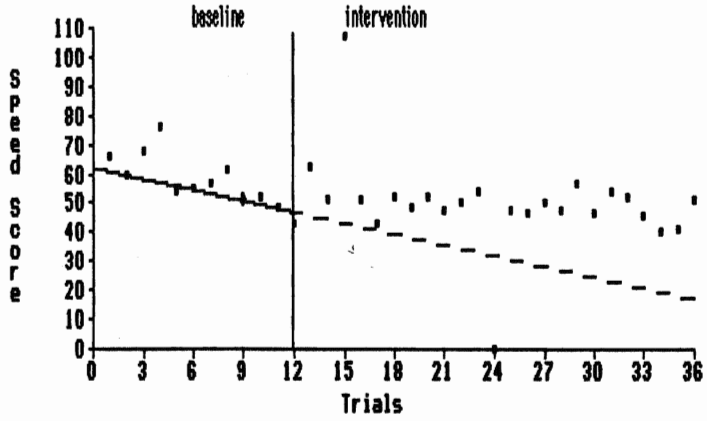

Figure 10. Speed scores of letter group 5 over time: child A

Statistical Analysis

The means (x) and standard deviations (S.D.) of quality and speed scores for child A are presented in Tables 1 - 5.

The means of quality scores for letter Group 1 decreased markedly during the series of trials administered prior to the intervention, with a slight increase in the mean following the intervention. Standard deviations decreased over time with the exception of series five which demonstrates an increased variance (Table 1).

The means of quality scores for letter Group 2 decreased significantly from Series 1 to Series 2, which immediately followed the intervention. Standard deviations also decreased markedly from Series 1 to Series 2 as child A demonstrated consistency following the intervention. There was a slight increase in the variance of the scores in subsequent series, however, not as great as that of the initial series (Table 2).

The means of quality scores for letter Group 3 were fairly consistent for the first three series of trials. Immediately following the intervention, the mean dropped significantly, and remained low for the remainder of the trials. Standard deviations were fairly consistent throughout the series with

the exception of Series 3 which had widely discrepant scores (Table 3).

The means of quality scores for letter Group 4 demonstrated a decline throughout the series with slight increases at Series 2 and 5. There was not a large decrease following intervention prior to Series 6. Standard deviations did decrease throughout with the variance in scores being least pronounced in Series 6 (Table 4).

The means of quality scores for letter Group 5 showed a decrease from Series 2 to Series 3, the series following intervention. There was a rise in the means of the two subsequent series before it decreased again. Standard deviations remained consistent throughout the trials (Table 5).

A data transformation was applied to the mean of all letter groups for Series 2 to 6. All letter groups subsequently received a ranking for the series following intervention, with the rankings as follows: letter Group 1 - 2, letter Group 2 - 1, letter Group 3 - 3, letter Group 4 - 1, and letter Group 5 - 1 (Table 6).

All ranks for individual letter groups were totalled for a global ranking of Rn = 8. The tabled value required for

significance at the .05 level for five behaviours is Rn = 6 (Barlow & Hersen, 1985); therefore, the change in quality scores for Child A was not statistically significant.

The means of speed scores for letter group 1 demonstrated a gradual decrease over time. The standard deviations for all series were consistent with the exception of the first series where a large variance was seen due to extremely high scores on the first two trials (Table 1).

The means of speed scores for letter Group 2 decrease markedly from Series 1 to 2, the series immediately following intervention. Following this, there was a slow decline in means to the end of the series. Standard deviations showed a decreasing trend, with fluctuations throughout the series. Variance was largest during the initial series (Table 2).

The means of speed scores for letter Group 3 declined gradually through the six series. There was a marginal decrease in the mean of the sixth series following the intervention. Standard deviations fluctuated considerably throughout the six series with variance greatest during the initial series (Table 3).

The means of letter Group 4 showed a pattern similar to that of letter Group 3 with a gradual decrease as the series progressed. The standard deviations for all series were fairly stable with the exception of Series 1, where the variance in scores was great due to extreme scores for Trials 3 and 5 (Table 4).

The means of letter Group 5 gradually decreased from Series 1 to 6, with the exception of a slight increase in Series 3, immediately following intervention. The standard deviation for this series was also incongruent due to an elevated speed score on Trial 15 (Table 5).

A data transformation was applied to the mean of all letter Groups for Series 2 to 6, and subsequent rankings were as follows: letter Group 1 - 2, letter Group 2 - 2, letter Group 3 - 1, letter Group 4 - 2, and letter Group 5 - 1 (Table 7).

All ranks of speed for individual groups were totalled, for a final rank of Rn = 8. This was not statistically significant at the .05 level as determined by Kapusky's table of maximum values (Barlow & Hersen, 1985).

Table 1
Mean Scores and Standard Deviations for Letter Group 1: Child A

	Quality		Speed	
Series	M	SD	M	SD
Entire	16.94	7.06	70.41	13.35
1	23.67	5.35	85.67	17.42
2	23.83	2.99	75.33	8.02
3	18.00	4.86	63.50	8.50
4	10.67	4.93	70.50	9.85
5*	11.33	5.13	66.83	9.77
6	11.00	2.37	60.67	9.37

Table 2
Mean Scores and Standard Deviations for Letter Group 2: Child A

	Quality		Speed	
Series	M	SD	M	SD
Entire	19.77	8.50	81.00	13.46
1	33.83	7.94	100.17	14.88
2*	21.50	3.83	83.33	12.45
3	15.00	4.73	82.50	5.36
4	16.20	4.02	73.60	1.52
5	16.50	6.02	72.33	9.35
6	15.00	4.52	72.83	7.88

Table 3
Mean Scores and Standard Deviations for Letter Group 3: Child A

	Quality		Speed	
Series	M	SD	M	SD
Entire	11.34	6.96	73.00	14.69
1	15.00	4.43	93.50	16.39
2	20.67	1.97	80.00	11.61
3	13.33	7.58	69.50	3.62
4*	7.00	3.32	66.60	7.02
5	6.50	2.17	63.83	11.77
6	4.83	3.43	63.50	6.69

* Denotes Series following intervention

Table 4
Mean Scores and Standard Deviations for Letter Group 4: Child A

	Quality		Speed	
Series	M	SD	M	SD
Entire	6.86	4.54	90.00	15.45
1	9.83	4.36	108.17	24.54
2	11.50	5.43	92.50	8.36
3	8.00	2.68	92.50	7.64
4	3.20	2.49	88.80	7.76
5	4.17	2.48	80.83	6.43
6*	3.83	1.47	77.00	9.30

Table 5
Mean Scores and Standard Deviations for Letter Group 5: Child A

	Quality		Speed	
Series	M	SD	M	SD
Entire	15.74	5.27	54.06	11.90
1	17.50	2.59	63.17	8.45
2	21.67	4.08	52.17	6.27
3*	12.67	5.12	61.00	23.33
4	16.20	3.63	50.60	2.41
5	15.67	5.39	49.50	3.83
6	10.83	3.60	47.33	5.92

Table 6
Data Transformation on Means of Quality Scores: Child A

	Series				
Letter Group	2	3	4	5	6
1	+.10	-.23	-.55	-.52(2)	
2	-.34(1)				
3	+.37	-.11	-.53(3)		
4	+.16	-.19	-.67	-.57	-.61(1)
5	+.23	-.27(1)			

The number in parentheses denotes the ranking accredited to the data transformation for the Series following intervention of a letter Group

Table 7
Data Transformation on Means of Speed Scores: Child A

	Series				
Letter Group	2	3	4	5	6
1	-.12	-.26	-.18	-.22(2)	
2	-.16(2)				
3	-.14	-.26	-.29(1)		
4	-.14	-.14	-.18	-.25	-.29(1)
5	-.17	-.03(4)			

Child B

Visual Analysis

Visual analysis of quality of letter Groups for child B indicated considerably more consistency in improvement from the baseline to intervention phase, while speed for the letter Groups demonstrated very little pattern at all.

The quality scores for letter Group 1 (Figure 11) demonstrated minimal variation during the baseline phase with a slight decreasing trend. There was an immediate decrease in scores following the intervention, with all data points throughout this phase remaining below the trend line. The change in trend was statistically significant at the .05 level.

A similar pattern emerged in the quality scores for letter Group 2 (Figure 12), with only a slight increase in the variance of scores during the baseline phase. All but two of the 23 data points in the intervention phase fell below the line. Bloom's probability table (Ottenbacher, 1986) requires that a minimum of 18 of the 23 data points be below the line in order for significance to occur, therefore the change in trend was statistically significant at the .05 level.

The quality scores for letter Group 3 (Figure 13) decreased markedly during the baseline phase, creating a trend line which reached the x-axis immediately following the intervention. Thus statistical significance for this letter Group was unmanageable.

The quality scores for letter Group 4 (Figure 14) decreased gradually through the baseline phase with a noticeable drop after the intervention. All data points during the intervention phase fell below the trend line making it statistically significant at the .05 level.

There was a wide variance of quality scores during the baseline of letter Group 5 (Figure 15). Eleven of the 16 data points in the intervention phase fell below the trend line; however, this is not enough for significance to occur.

The speed scores for letter Group 1 (Figure 16) were widely discrepant during the baseline phase, with an increasing trend following intervention. There was not statistical significance at the .05 level.

A similar pattern to that of quality scores for Group 3 occurred with the speed scores of letter Group 2 (Figure 17). The trend line fell dramatically, reaching the x-axis

immediately following intervention. Statistical significance was not achievable.

The speed scores for letter Group 3 (Figure 18) demonstrated a slightly increasing trend during the baseline phase. There was a decrease following the intervention, and all subsequent scores fell below the trend line, yielding statistical significance at the .05 level.

The speed scores for letter Group 4 (Figure 19) demonstrated a noticeably increasing trend through the baseline phase, with scores falling off following the intervention. All data points during the intervention phase fell below the trend line, making it statistically significant at the .05 level.

The speed scores of letter Group 5 (Figure 20) showed a wide variance of scores through both the baseline and intervention phases. There was no change in trend from one phase to the other, therefore statistical significance did not occur.

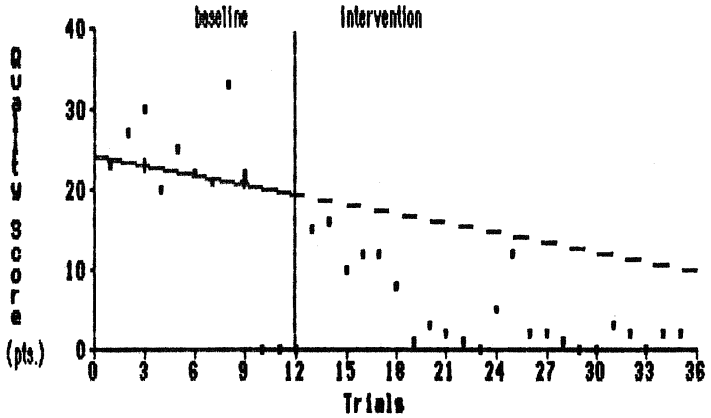

Figure 11. Quality scores of letter group 1 over time: child B

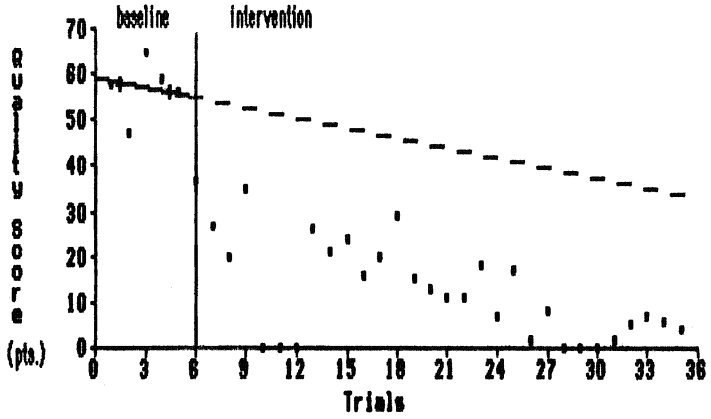

Figure 12. Quality scores of letter group 2 over time: child B

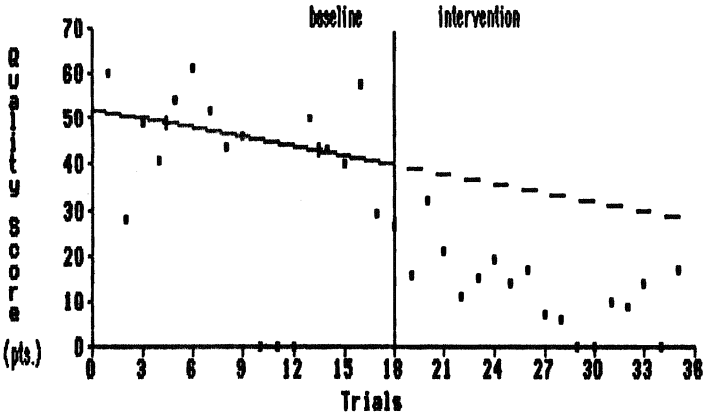

Figure 13. Quality scores of letter group 3 over time: child B

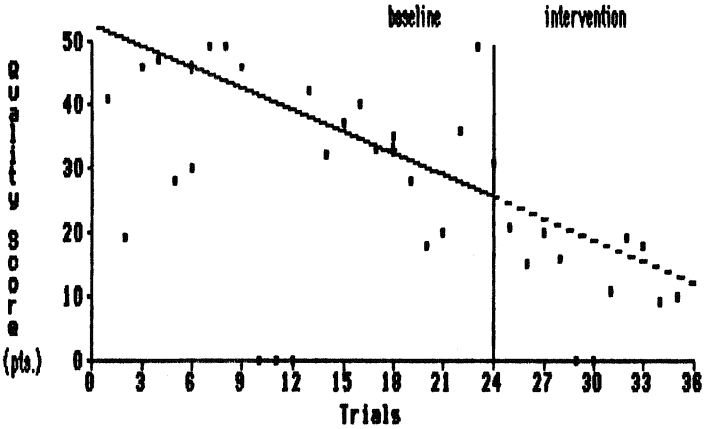

Figure 14. Quality scores of letter group 4 over time: child B

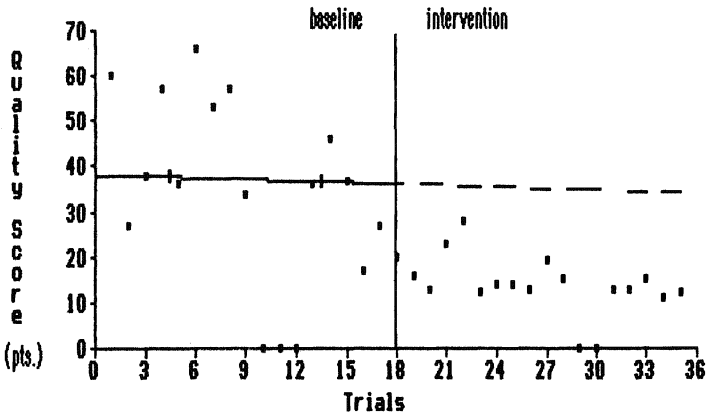

Figure 15. Quality scores of letter group 5 over time: child B

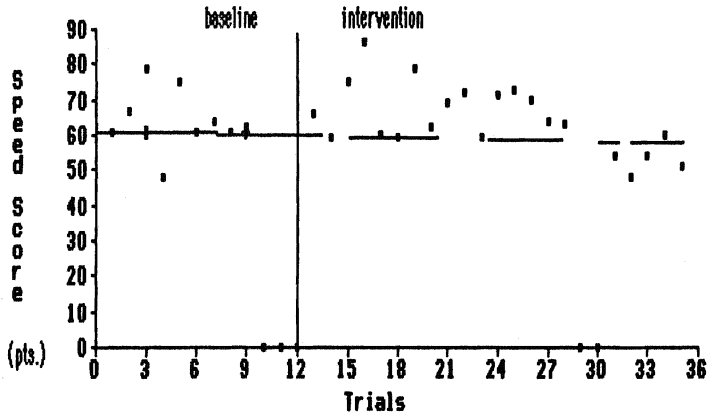

Figure 16. Speed scores of letter group 1 over time: child B

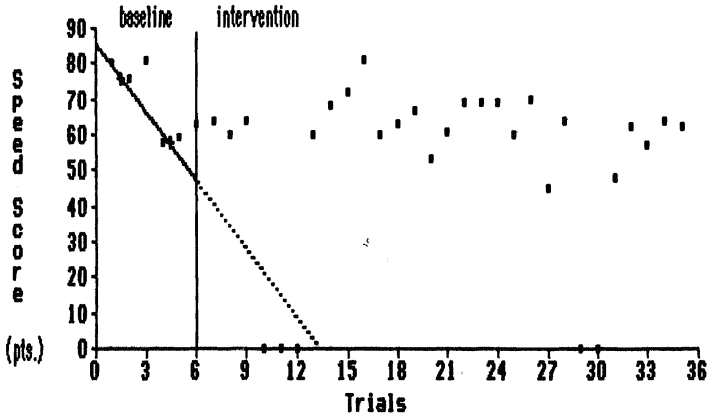

Figure 17. Speed scores of letter group 2 over time: child B

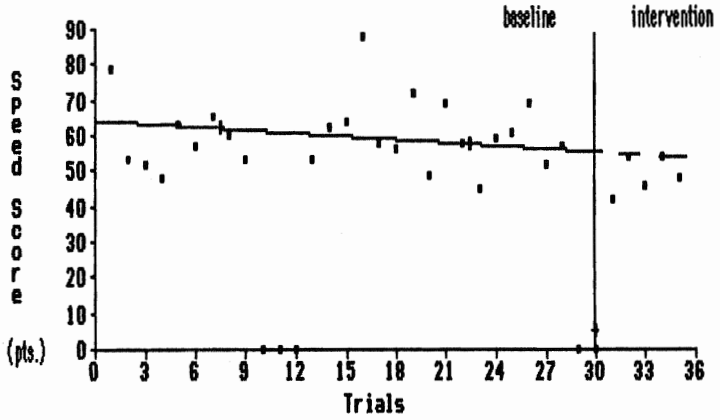

Figure 18. Speed scores of letter group 3 over time: child B

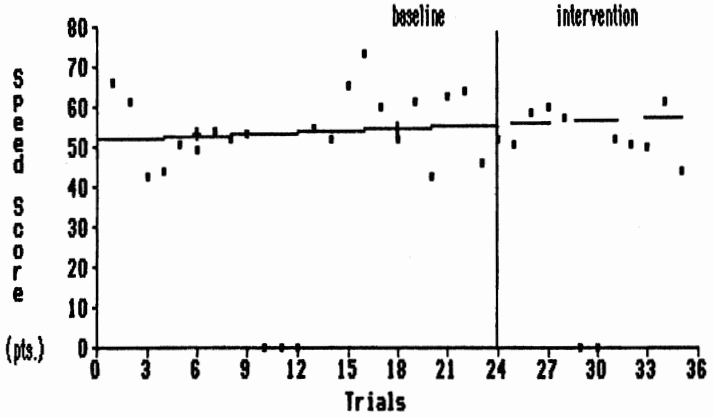

Figure 19. Speed scores of letter group 4 over time: child B

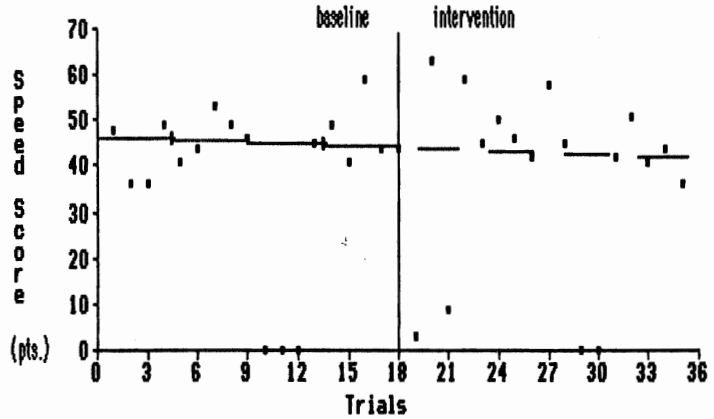

Figure 20. Speed scores of letter group 5 over time: child B

Statistical Analysis

The means and standard deviations of quality and speed scores for child B are presented in Tables 8 - 12.

The means of quality scores for letter Group 1 showed a significant decrease from Series 2 to Series 3, which immediately followed intervention. There was a further decrease from Series 3 to 4, with no further significant changes in the final two series. There were fluctuations in standard deviations throughout the six series, however no evident pattern from beginning to end (Table 8).

The means of quality scores for letter Group 2 demonstrated a decrease from Series 1 to 2, following intervention. There were noticeable decreases in each of the subsequent series also. The standard deviation was greatest in Series 1, with decreases occurring in all subsequent series but Series 5 (Table 9).

The means of quality scores for letter Group 3 showed a pattern similar to that of letter Group 2 with decreases throughout the six series, including Series 5 which followed intervention. Standard deviations were generally lowest in latter series with the exception of Series 2, where there was minimal variance in scores (Table 10).

The means of quality scores for letter Group 4 demonstrate an increase from Series 1 to 2, with decreases in subsequent series including Series 5 which followed intervention. Standard deviations were extremely varied, with no evident pattern from beginning to end (Table 11).

The means of quality scores for letter Group 5 again decreased consistently through the six series, with the largest jump occurring at Series 4, following the intervention. Standard deviations showed a similar decline as quality scores became more consistent (Table 12).

A data transformation was applied to the mean of letter groups for Series 2 to 6, and subsequent rankings of letter groups following intervention were as follows: letter Group 1 - 1, letter Group 2 - 1, letter Group 3 - 1, letter Group 4 - 2, and letter Group 5 - 1 (Table 13).

All ranks of quality for individual groups were totalled, for a final rank of Rn = 6. Since this equals the tabled value needed for statistical significance, the decrease in quality scores for child B was statistically significant at the .05 level.

The means of speed scores for letter Group 1 remained very stable throughout 5 of the 6 series, with the only

noticeable decrease occurring in the final series. There were more fluctuations in standard deviations, with the greatest amount of variance in scores occurring in the first series, due to a particularly low score on Trial 4, and in Series 3, where Trial 13 was particularly high (Table 8).

As in letter Group 1, the means of speed scores for letter Group 2 remained relatively consistent throughout the six series. There was only a slight decrease following intervention at the beginning of Series 2. There were marked fluctuations in the standard deviations, with the greatest consistency in scores occurring in Series 2, immediately after the intervention (Table 9).

Means of speed scores for letter Group 3 were very consistent through the first five series. Following intervention prior to Series 6, there was a significant drop in the mean score. The standard deviation was also lowest in Series 6. There was considerably more variance in scores in earlier series (Table 10).

The means of speed scores for letter Group 4 remained very consistent throughout all series. There was no decrease following intervention at the start of Series 5. Standard deviations were somewhat more scattered, with a slight

increase in consistency of scores following the intervention (Table 11).

The means of speed scores for letter Group 5 demonstrated minimal changes throughout, with the exception of Series 4, following intervention, at which point there was an increase. Standard deviations were relatively consistent throughout the six series (Table 12).

Following a data transformation on the mean of all letter groups for Series 2 to 6, a ranking was applied to letter groups following intervention as follows: letter Group 1 - 1, letter Group 2 - 1, letter Group 3 - 1, letter Group 4 - 2, and letter Group 5 - 3 (Table 14).

All ranks for individual letter groups were summed for a total ranking of Rn = 8, exceeding the maximum value of Rn = 6. Therefore, there was not statistical significance in change at the .05 level.

Table 8
Mean Scores and Standard Deviations for Letter Group 1: Child B

	Quality		Speed	
Series	M	SD	M	SD
Entire	10.77	10.38	63.71	9.84
1	24.50	3.62	65.17	11.14
2	25.33	6.66	62.33	1.53
3*	12.17	2.99	67.50	10.97
4	2.00	1.79	68.67	7.23
5	4.25	5.19	67.50	4.80
6	1.50	1.22	51.67	5.82

Table 9
Mean Scores and Standard Deviations for Letter Group 2: Child B

	Quality		Speed	
Series	M	SD	M	SD
Entire	21.52	18.68	63.71	9.09
1	53.67	10.03	69.50	10.67
2*	27.33	7.51	62.67	2.31
3	22.67	4.63	67.33	8.19
4	12.50	3.78	64.67	6.50
5	6.75	7.63	60.00	10.98
6	4.17	2.32	56.33	8.02

Table 10
Mean Scores and Standard Deviations for Letter Group 3: Child B

	Quality		Speed	
Series	M	SD	M	SD
Entire	28.84	18.75	57.65	10.39
1	48.83	12.61	58.67	11.18
2	47.33	4.16	59.33	6.03
3	41.00	12.20	63.50	12.65
4	18.83	6.88	58.67	10.63
5	11.00	5.35	59.75	7.18
6*	9.33	5.99	47.50	5.65

Table 11
Mean Scores and Standard Deviations for Letter Group 4: Child B

	Quality		Speed	
Series	M	SD	M	SD
Entire	30.32	13.26	54.65	7.44
1	40.17	9.06	52.33	9.29
2	48.00	1.73	53.00	1.00
3	36.50	3.94	59.00	8.31
4*	30.33	11.36	54.83	9.11
5	18.00	2.94	56.75	4.03
6	13.67	4.27	51.33	5.50

Table 12
Mean Scores and Standard Deviations for Letter Group 5: Child B

	Quality		Speed	
Series	M	SD	M	SD
Entire	27.77	16.72	46.10	7.42
1	47.33	15.69	42.33	5.68
2	48.00	12.29	49.33	3.51
3	30.50	11.11	47.00	6.42
4*	17.67	6.41	54.25	8.22
5	15.25	2.63	47.75	7.04
6	13.83	2.86	40.83	6.85

Table 13
Data Transformation on Means of Quality Scores: Child B

	Series				
Letter Group	2	3	4	5	6
1	+.03	-.50(1)			
2	-.49(1)				
3	-.03	-.16	-.61	-.77	-.71(1)
4	+.20	-.09	-.25	-.55(2)	
5	+.01	-.35	-.63(1)		

Table 14
Data Transformation on Means of Speed Scores: Child B

	Series				
Letter Group	2	3	4	5	6
1	-.04	+.04(1)			
2	-.10(1)				
3	+.01	+.08	0.0	+.02	.19(1)
4	+.01	+.14	+.04	+.08(2)	
5	+.16	+.11	+.28(3)		

Child C

Visual Analysis

Visual analysis of quality and speed scores of all letter Groups for child C indicated considerable variance in improvement from the baseline to intervention phase.

The quality scores for letter Group 1 are plotted on the graph in Figure 21. Only two trials were administered prior to the intervention, thus a trend line could not be computed.

The quality scores for letter Group 2 decreased during the baseline phase (Figure 22), continued to decrease following intervention. However, the trend line reached the x-axis prior to the end of the trials, so that most of the data points post-intervention remained above it. Significance was not achieved at the .05 level.

There was a very significant decrease in quality scores of letter Group 3 during the baseline phase (Figure 23). Again, while scores continued to drop following the intervention, very few of the data points during this phase fell below the trend line. There was not statistical significance at the .05 level.

The quality scores for letter Group 4 are plotted on the graph in Figure 24. While there was a decrease in scores following intervention, only four post-intervention trials were completed. The minimum number of post-intervention data points needed to compute statistical significance is six.

Quality scores for letter Group 5 (Figure 25) present a pattern similar to that of letter Group 3. The trend line reached the x-axis immediately following the intervention; thus, all post-intervention data points remained above it. Statistical significance was not achieved.

The speed scores for letter Group 1 are plotted on the graph in Figure 26. As in the quality scores for letter Group 1, only two trials were administered prior to intervention, and therefore a trend line could not be drawn.

The speed scores for letter Group 2 (Figure 27) remained extremely consistent throughout the 36 trials. There was minimal change in trend as determined by the trend line, therefore statistical significance at the .05 level was not achieved.

The speed scores for letter Group 3 (Figure 28) gradually decreased through the baseline phase, then dropped sharply following intervention. Nineteen of the 21 post-intervention

data points fell below the trend line, the minimum number required to achieve significance at the .05 level being seventeen.

The speed scores for letter Group 4 are plotted on the graph in Figure 29. As in the quality scores for letter Group 4, only 4 post-intervention trials were administered, thus statistical significance could not be calculated.

As in the quality scores for letter Group 5, the speed scores for this letter Group (Figure 30) decreased dramatically during the baseline phase, and in this case, the trend line reached the x-axis at the point of intervention. All data points following intervention obviously remained above the trend line, thus significance was not achieved.

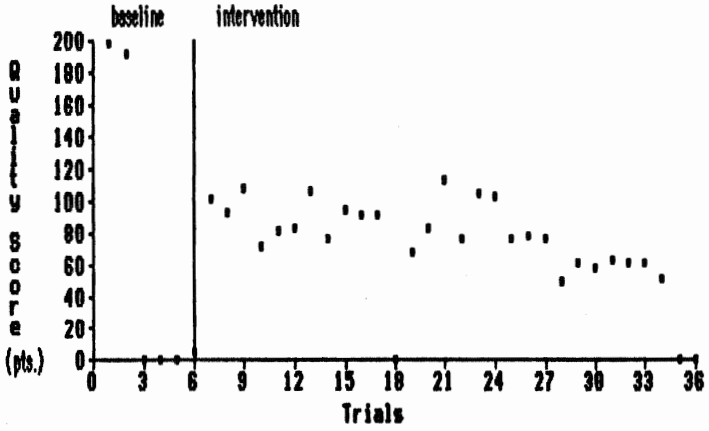

Figure 21. Quality scores of letter group 1 over time: child C

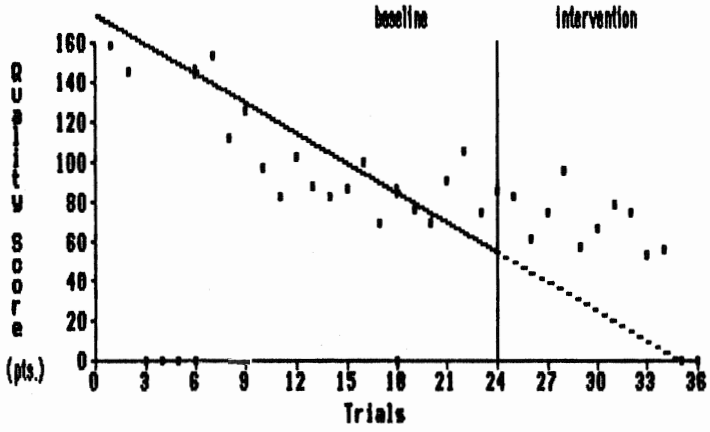

Figure 22. Quality scores of letter group 2 over time: child C

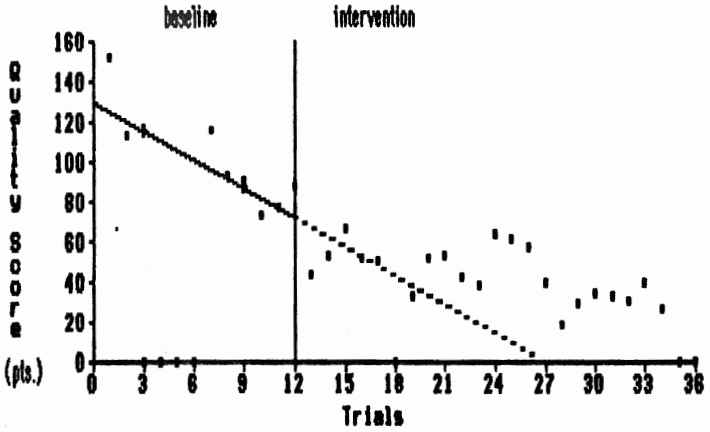

Figure 23. Quality scores of letter group 3 over time: child C

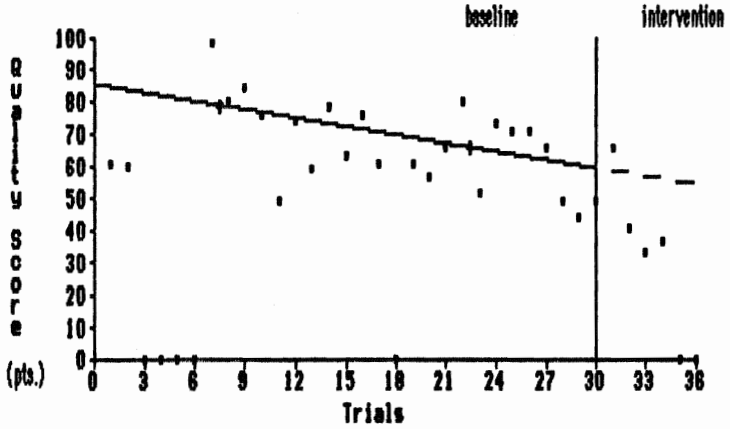

Figure 24. Quality scores of letter group 4 over time: child C

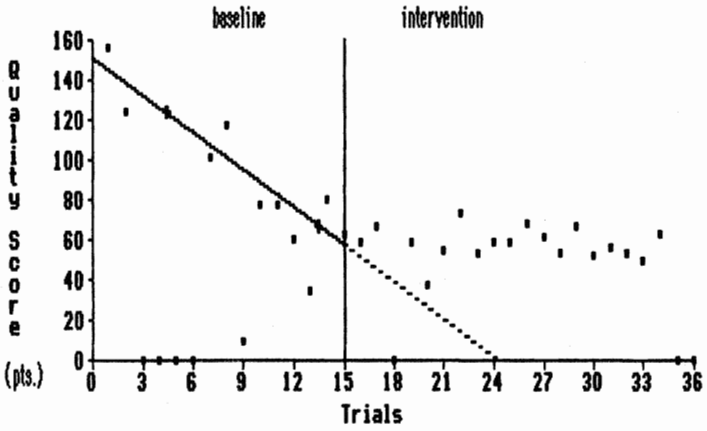

Figure 25. Quality scores of letter group 5 over time: child C

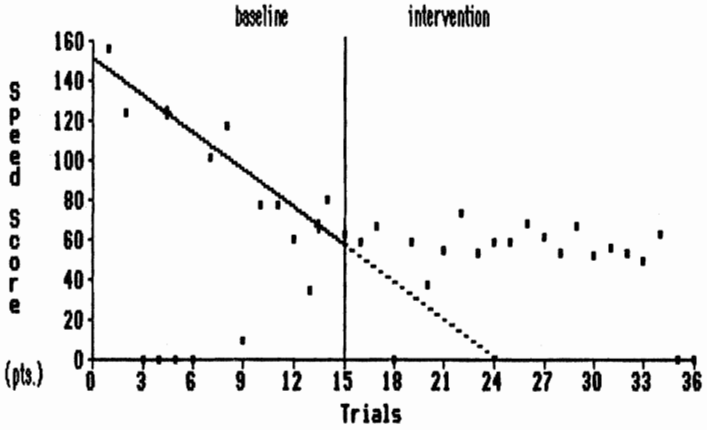

Figure 26. Speed scores of letter group 1 over time: child C

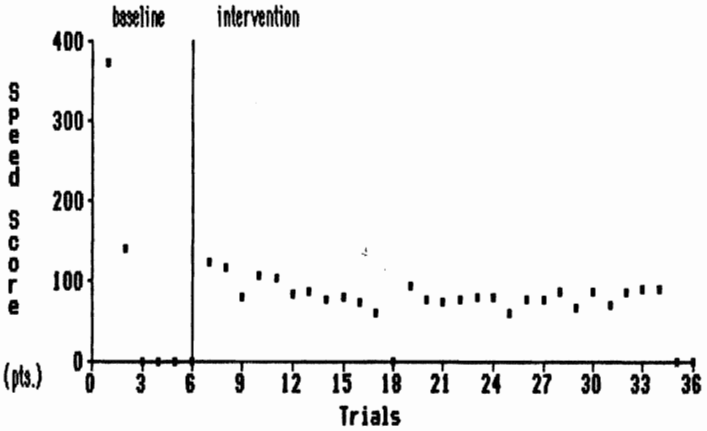

Figure 27. Speed scores of letter group 2 over time: child C

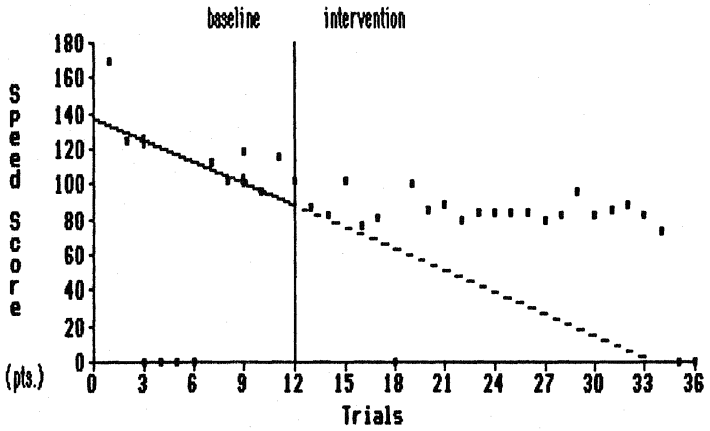

Figure 28. Speed scores of letter group 3 over time: child C

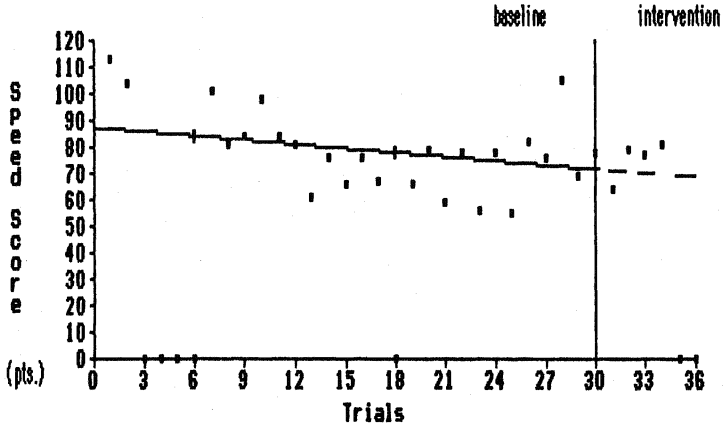

Figure 29. Speed scores of letter group 4 over time: child C

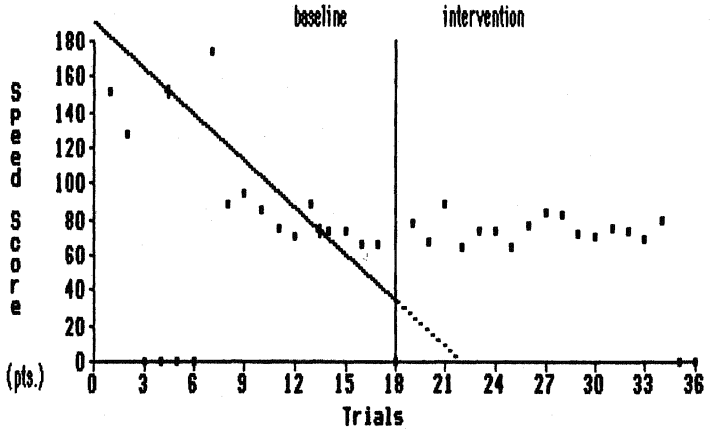

Figure 30. Speed scores of letter group 5 over time: child C

Statistical Analysis

The means and standard deviations of quality and speed scores for child C are presented in Tables 15 - 19.

The means of quality scores for letter Group 1 decreased significantly from Series 1 to 2, the series of trials administered immediately following intervention. Mean scores remained fairly stable following this. Standard deviations were very low for the first series, with an increase in variance of scores following intervention. Scores became more consistent again during the final series of trials (Table 15).

The means of quality scores for letter Group 2 decreased through the first three series, stabilized, then fell again immediately following intervention at the beginning of Series 5. There was a great deal of variation in the standard deviations with the least degree of variance of scores being found in Series 5 (Table 16).

The means of quality scores for letter Group 3 showed a marked decrease from Series 1 to Series 3, the series following intervention, with the mean scores remaining fairly consistent after this. Again, the standard deviation was low in the series following intervention with an

increase in subsequent series before another decrease in variance in the final series (Table 17).

The means of quality scores for letter Group 4 demonstrated remarkable consistency throughout the entire set of series, with a slight drop in the final series following intervention. The standard deviation was extremely low in the initial series since the only two trials administered produced similar scores. It then rose, remaining fairly consistent to the end of the six series (Table 18).

The means of quality scores for letter Group 5 demonstrated a decrease through the first three series, prior to intervention. There was no significant decrease in mean scores following intervention. Standard deviations for letter Group 5 decreased with each series, with the most noticeable drops occurring following intervention, in Series 4 and 5 (Table 19).

A data transformation was applied to the mean of all letter groups for Series 2 to 6, and a subsequent ranking applied to letter groups as follows: letter Group 1 - 2, letter Group 2 - 1, letter Group 3 - 3, letter Group 4 - 1, and letter Group 5 - 2 (Table 20).

All ranks for individual letter groups were totalled for a global ranking of Rn = 9. Since this exceeded the maximum value of Rn = 6, the change in quality scores was not statistically significant at the .05 level.

The means of speed scores for letter Group 1 showed the greatest deal of change from Series 1 to 2, following intervention. Subsequent decreases were much smaller, with the means for Series 4 through 6 remaining constant. There was remarkable variance during Series 1, due to a wide discrepancy between the scores of the two trials in this series. Scores stabilized following intervention (Table 15).

The means of speed scores for letter Group 2, again showed the greatest deal of change from Series 1 to 2. There was another moderate decrease form Series 2 to 3 before means became somewhat consistent. The standard deviation was again high during Series 1, with scores stabilizing in subsequent series (Table 16).

The means of speed scores for letter Group 3 demonstrate a drop from Series 1 to 2, and again from 2 to 3, the series following intervention. The remainder of the series remain constant in mean scores. The standard deviation was greatest in Series 1 as is the case in previous letter groups for

child C. Scores were much more consistent in the last five series (Table 17).

The means of speed scores for letter Group 4 decreased from Series 1 to 2, the remained fairly consistent. There was no decrease after intervention at Series 6. Standard deviations varied moderately with variance being greatest just prior to intervention (Table 18).

The means of speed scores for letter Group 5 were again extremely high, with a drop from Series 1 to 2, and again from 2 to 3. There was no decrease following intervention at Series 4. Standard deviations were also highest in the first two series indicating a wide variance of scores prior to intervention (Table 19).

A data transformation was applied to the mean of all letter Groups for Series 2 to 6, and letter Groups subsequently received the following rankings: letter Group 1 - 2, letter Group 2 - 1, letter Group 3 - 3, letter Group 4 - 1, and letter Group 5 - 2 (Table 21).

All ranks for individual letter groups were totalled for a global ranking of Rn = 9. This exceeded the maximum value need for significance, therefore there was not statistical significance at the .05 level.

Table 15
Mean Scores and Standard Deviations for Letter Group 1: Child C

	Quality		Speed	
Series	M	SD	M	SD
Entire	88.90	34.21	110.79	37.54
1	195.00	4.24	208.50	101.12
2*	89.83	13.53	129.50	13.65
3	91.80	10.76	104.40	16.62
4	91.83	17.90	94.00	8.27
5	66.83	11.81	93.83	9.70
6	59.50	5.07	92.50	8.66

Table 16
Mean Scores and Standard Deviations for Letter Group 2: Child C

	Quality		Speed	
Series	M	SD	M	SD
Entire	88.90	27.73	95.52	56.15
1	152.00	9.90	256.00	164.05
2	112.17	24.48	102.67	17.47
3	85.40	11.15	74.80	9.09
4	83.50	13.03	79.67	7.66
5*	68.50	9.46	75.33	10.50
6	65.50	12.92	84.50	9.43

Table 17
Mean Scores and Standard Deviations for Letter Group 3: Child C

	Quality		Speed	
Series	M	SD	M	SD
Entire	59.62	30.78	94.14	19.51
1	132.50	27.58	146.50	31.82
2	89.83	14.99	107.83	9.00
3*	53.40	8.38	86.00	9.64
4	47.33	11.38	86.83	7.11
5	40.50	16.36	84.50	5.92
6	32.75	5.44	83.00	6.48

Table 18
Mean Scores and Standard Deviations for Letter Group 4: Child C

	Quality		Speed	
Series	M	SD	M	SD
Entire	63.28	15.10	78.41	14.68
1	60.50	.70	108.50	6.36
2	76.83	16.08	88.17	8.93
3	67.40	8.90	69.20	6.61
4	64.83	10.38	69.33	10.39
5	58.33	12.32	77.50	16.48
6*	44.25	14.86	77.25	7.68

Table 19
Mean Scores and Standard Deviations for Letter Group 5: Child C

	Quality		Speed	
Series	M	SD	M	SD
Entire	69.86	26.29	83.79	25.34
1	140.00	22.27	139.50	17.68
2	87.50	20.51	98.17	38.14
3	60.80	16.44	73.80	9.40
4*	56.00	11.19	74.33	8.82
5	60.00	6.60	75.00	7.64
6	55.25	5.91	74.25	4.11

Table 20
Data Transformation on Means of Quality Scores: Child C

	Series				
Letter Group	2	3	4	5	6
1	-.54(1)				
2	-.26	-.53	-.45	-.55(1)	
3	-.32	-.44(3)			
4	+.26	+.11	+.07	-.04	-.27(1)
5	-.38	-.57	-.06(2)		

Table 21
Data Transformation on Means of Speed Scores: Child C

	Series				
Letter Group	2	3	4	5	6
1	-.38(2)				
2	-.59	-.71	-.69	-.55(1)	
3	-.26	-.41(3)			
4	-.23	-.36	-.36	-.29	-.31(1)
5	-.29	-.47	-.47(2)		

Child D

Visual Analysis

Visual analysis of quality and speed of all letter Groups for child D indicates a great deal of variance of change from the baseline to the intervention phase.

The quality scores for letter Group 1 (Figure 31) demonstrated a gradually increasing trend during the baseline phase. There was a significant decrease in scores at the time of intervention, with all data points in the post-intervention phase remaining below the trend line. There was significance at the .05 level.

The quality scores for letter Group 2 (Figure 32) demonstrated considerable variation during the baseline phase. While there was a decrease in scores following intervention, only four post-test trials were completed, therefore statistical significance could not be computed.

The quality scores for letter Group 3 (Figure 33) demonstrated a decreasing trend during the baseline phase with scores remaining constant during the post-intervention phase. All data points, therefore, remained above the trend line, and significance at the .05 level was not achieved.

A similar pattern was seen in the quality scores of letter Group 4 (Figure 34). There was no change in trend between the baseline and the post-intervention phase, and statistical significance did not occur.

The quality scores for letter Group 5 (Figure 35) again decreased through the baseline phase, without a similar decrease during the post-intervention phase. All but one of the data points remained above the trend line, and there was no statistical significance.

The speed scores for letter Group 1 (Figure 36) showed a slightly decreasing trend in scores during the baseline phase, with a marked increase following intervention. There was no statistical significance at the .05 level.

The speed scores for letter Group 2 (Figure 37) remained extremely consistent throughout both the baseline and post-intervention phases. There was not statistical significance.

The speed scores for letter Group 3 (Figure 38) decreased dramatically during the baseline, with the trend line reaching the x-axis immediately following intervention. Thus, all data points remained above the line, and significance was not achieved.

The speed scores for letter Group 4 (Figure 39) fell more gradually during the baseline phase, with scores remaining constant through the post-intervention phase. There was no statistical significance at the .05 level.

As in letter Group 3, the speed scores for letter Group 5 (Figure 40) decreased sharply during the baseline phase so that the trend line reached the x-axis at the point of intervention. Statistical significance was unmanageable.

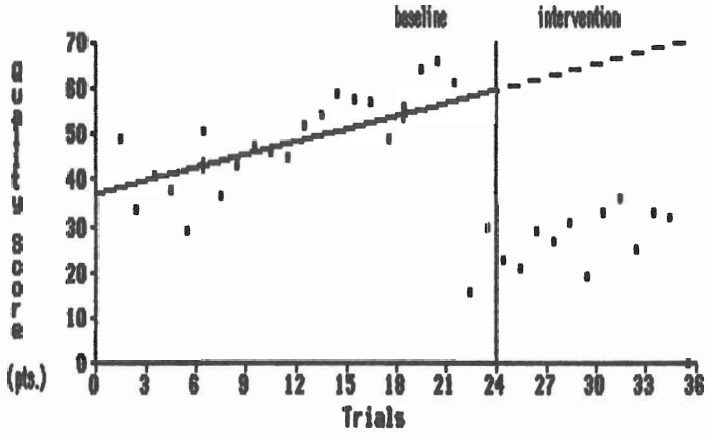

Figure 31. Quality scores of letter group 1 over time: child D

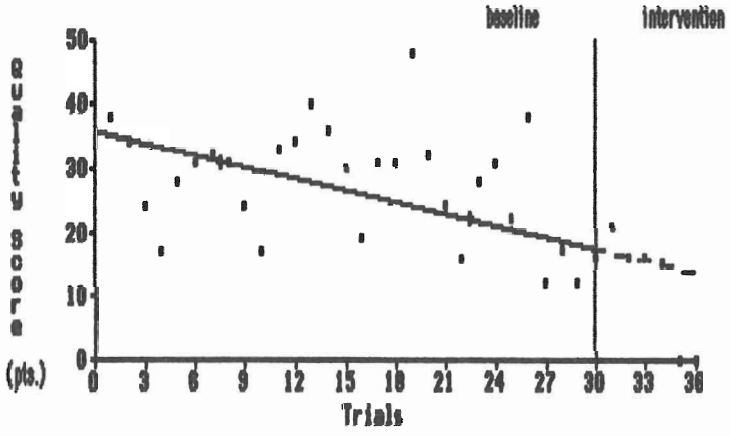

Figure 32. Quality scores of letter group 2 over time: child D

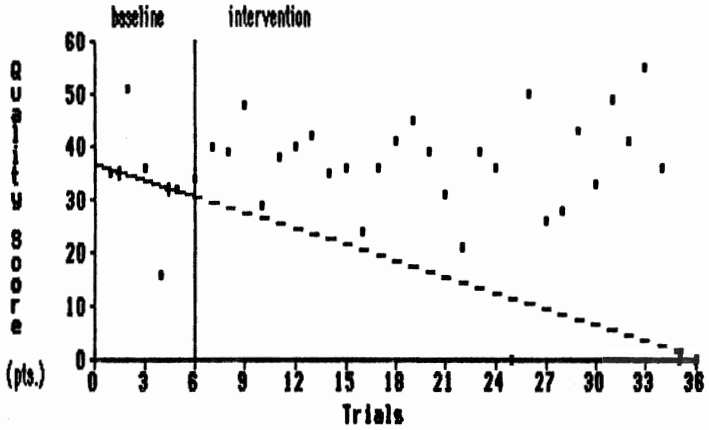

Figure 33. Quality scores of letter group 3 over time: child D

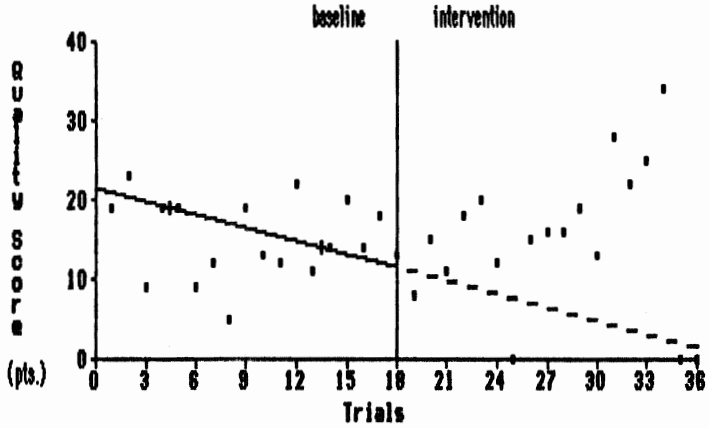

Figure 34. Quality scores of letter group 4 over time: child D

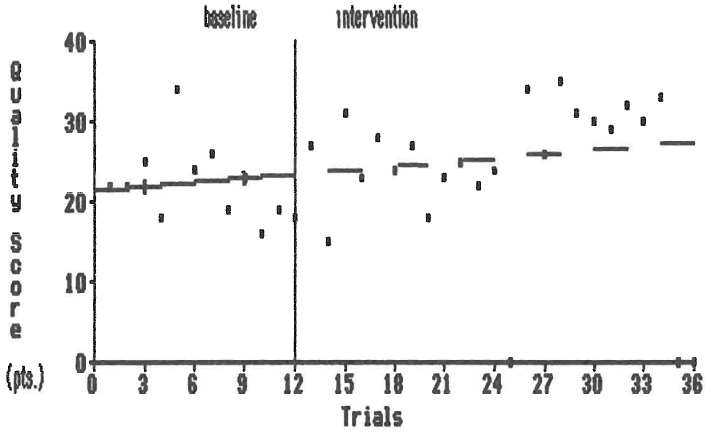

Figure 35. Quality scores of letter group 5 over time: child D

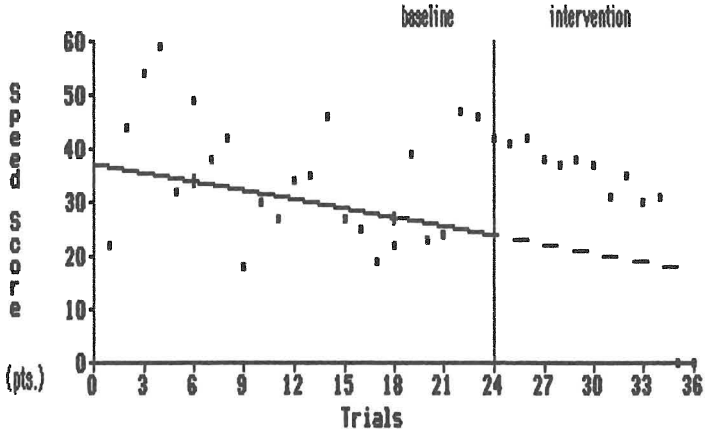

Figure 36. Speed scores of letter group 1 over time: child D

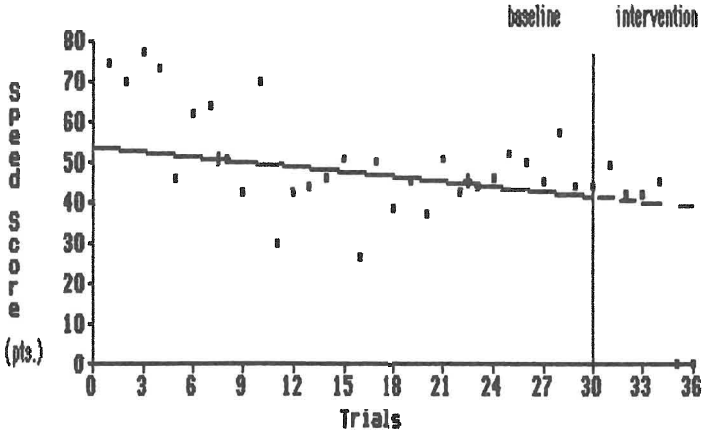

Figure 37. Speed scores of letter group 2 over time: child D

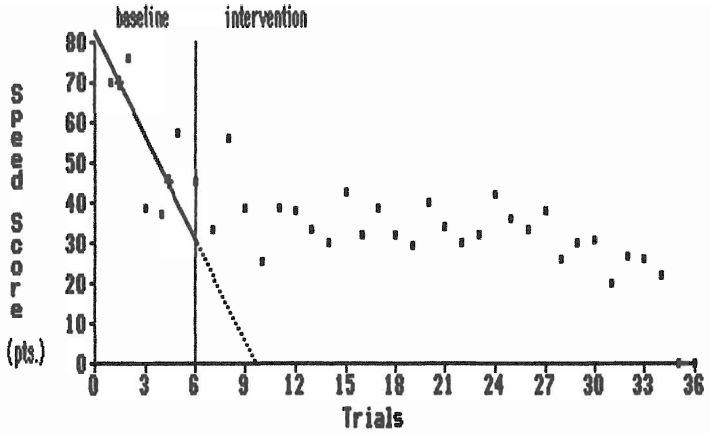

Figure 38. Speed scores of letter group 3 over time: child D

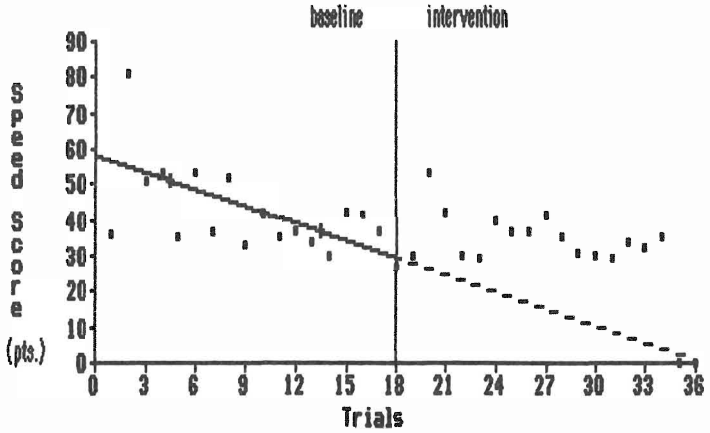

Figure 39. Speed scores of letter group 4 over time: child D

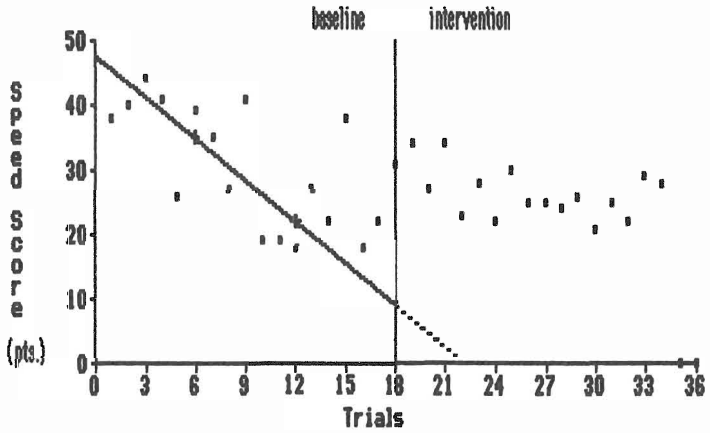

Figure 40. Speed scores of letter group 5 over time: child D

Statistical Analysis

The means and standard deviations of quality and speed scores for child D are presented in Tables 22 - 26.

The means of quality scores for letter Group 1 remained fairly consistent for the first four series before decreasing following intervention prior to Series 5. The standard deviations for all series were very consistent with the exception of Series 4 during which time considerable variance in scores occured (Table 22).

The means of quality scores for letter Group 2 decreased from Series 1 to 2, the series following intervention, with another slight decrease in the following series before the means stabilized. Standard deviations were fairly stable throughout all six series (Table 23).

The means of quality scores for letter Group 3 were very consistent through the first five series with an increase in Series 6. Standard deviations showed variance in the scores of Series 1 and 5, with more consistent scores during the other series (Table 24).

The means of quality scores for letter Group 4 were very inconsistent with very low scores in Series 2 and 4, the

latter following intervention. All other series were considerably higher with the sixth and final series being the highest. Standard deviations were very consistent throughout all six series (Table 25).

The means of quality scores for letter Group 5 remained very stable throughout the entire set of series with a slight increase in the final one. Standard deviations were also extremely consistent with the exception of Series 5 where there was considerably more variance (Table 26).

A data transformation, applied to the mean of all letter groups for Series 2 to 6 yielded the following rankings for letter groups following intervention: letter Group 1 - 1, letter Group 2 - 1, letter Group 3 - 5, letter Group 4 - 1, and letter Group 5 - 2 (Table 27).

All ranks of quality for individual groups were summed, for a final rank of Rn = 10. This value was not statistically significant at the .05 level as determined by Kapusky's table (Barlow & Hersen, 1985).

The means of speed scores for letter Group 1 remained very stable during the six series with no decrease in Series 6 following intervention. Standard deviations were high during

the first four series, but considerably lower following intervention (Table 22).

The means of speed scores for letter Group 2 remained consistent through the first five series, with a significant decrease in Series 6 following intervention. Standard deviations were highest in the initial series due to a very low score on Trial 3, with a gradual decrease following this (Table 23).

The means of speed scores for letter Group 3 decreased from a high during Series 1, and remained extremely stable through the rest of the series. Standard deviations decreased from Series 1 to Series 3, then levelled off for the final three series (Table 24).

The means of speed scores for letter Group 4 followed a similar pattern to those of letter Group 1 in that they decreased following Series 1, and then stabilized. The standard deviation was also highest for Series 1, with a decrease in variance of scores in subsequent series (Table 25).

The means of speed scores for letter Group 5 again followed a pattern similar to those of letter Groups 3 and 4 so that the mean in Series 1 was significantly higher than the rest,

which were very flat. Standard deviations varied little throughout the six series (Table 26).

Following a data transformation on the mean of all letter groups for Series 2 to 6, letter groups received a ranking as follows: letter Group 1 - 2, letter Group 2 - 1, letter Group 3 - 1, letter Group 4 - 1, and letter Group 5 - 3 (Table 28).

All ranks of speed for individual groups were totalled, for a final rank of Rn = 8. This value is not statistically significant at the .05 level.

Table 22
Mean Scores and Standard Deviations for Letter Group 1: Child D

	Quality		Speed	
Series	M	SD	M	SD
Entire	41.00	13.76	35.44	10.00
1	40.33	8.52	43.33	13.97
2	45.00	4.94	31.67	8.69
3	55.50	3.62	29.00	9.94
4	43.83	22.26	36.83	10.72
5*	26.67	5.57	38.83	2.14
6	31.50	4.65	31.75	2.22

Table 23
Mean Scores and Standard Deviations for Letter Group 2: Child D

	Quality		Speed	
Series	M	SD	M	SD
Entire	26.29	9.08	47.56	13.05
1	28.67	7.48	53.83	25.83
2	28.50	6.66	50.17	14.80
3	31.17	7.08	42.83	8.89
4	29.83	10.63	44.33	4.55
5	19.50	9.80	48.67	5.28
6*	17.00	2.71	4.50	3.32

Table 24
Mean Scores and Standard Deviations for Letter Group 3: Child D

	Quality		Speed	
Series	M	SD	M	SD
Entire	36.00	10.60	32.03	12.19
1	34.00	11.15	54.00	16.40
2*	39.00	6.07	38.33	10.19
3	35.67	6.41	34.83	5.04
4	35.17	8.30	34.50	5.36
5	30.00	17.31	32.33	4.32
6	45.25	8.42	32.75	3.30

Table 25
Mean Scores and Standard Deviations for Letter Group 4: Child D

	Quality		Speed	
Series	M	SD	M	SD
Entire	15.97	6.58	38.85	10.53
1	16.33	5.89	51.50	16.66
2	1.83	5.98	39.33	6.89
3	15.00	3.35	35.17	5.98
4*	1.00	4.52	37.33	9.50
5	13.17	6.74	35.17	4.12
6	27.25	5.12	32.50	2.65

Table 26
Mean Scores and Standard Deviations for Letter Group 5: Child D

	Quality		Speed	
Series	M	SD	M	SD
Entire	24.50	6.94	28.47	7.43
1	24.17	5.38	38.00	6.23
2	20.17	3.66	26.50	9.67
3*	24.67	5.54	26.33	7.28
4	23.17	3.06	28.00	5.18
5	26.00	13.13	25.17	2.93
6	31.00	1.83	26.00	3.17

Table 27
Data Transformation on Means of Quality Scores: Child D

	Series				
Letter Group	2	3	4	5	6
1	+.12	+.38	0.0	-.34(1)	
2	-.01	+.09	+.04	-.32	-.41(1)
3	+.14(5)				
4	-.15	-.08	-.14(1)		
5	-.17	+.02(2)			

Table 28
Data Transformation on Means of Speed Scores: Child D

	Series				
Letter Group	2	3	4	5	6
1	-.27	-.33	-.15	-.10(2)	
2	-.07	-.20	-.18	-.18	-.17(1)
3	-.29(1)				
4	-.24	-.32	-.28(1)		
5	-.30	-.31(3)			

Summary of Results Relating to Hypotheses

In conclusion, the first hypothesis stated in chapter 1 was that, following each of five sessions of a multisensory writing program, four children with sensorimotor difficulties exhibit a statistically significant improvement in quality scores on the letter group learned during the preceding session. This hypothesis was supported for child C, but for none of the other children.

The second hypothesis stated was that, following each of five sessions of a multisensory writing program, four children with sensorimotor difficulties exhibit a statistically significant improvement in speed scores on the letter group learned during the preceding session. This hypothesis was not supported for any of the children. However, there were definite patterns that occurred across all four children in areas of both visual and statistical analysis.

All children demonstrated a decreasing trend in most of their trend lines during the baseline phase of trials. As a result, while decreases were often noted following intervention, they were frequently not great enough for the

post-intervention data points to fall below the decreasing trend line.

The means of both quality and speed scores for all four children were usually highest during the first series. While there was a general decrease in subsequent series, in quality scores the decrease was often greatest in the series following intervention. Contrary to this, an increase often occurred following intervention for the speed scores.

The standard deviations for all four children were usually highest in the first Series where a great deal of variance of scores occurred, in both the quality and speed measures. While there was a general decrease in subsequent series, the largest drops in standard deviations frequently occurred in the series immediately following intervention.

Since decreases in means following intervention were much more frequent in quality rather than speed measures, it is not surprising that global rankings for quality were considerably lower than those for speed for three of the four children. Child D's scores presented a different pattern, and possible explanations for this pattern will be discussed in the next chapter.

Test of Written Language

Each child was administered the Handwriting, Vocabulary and Thematic Maturity components of the TOWL prior to and following the completion of the trials. The tests were subsequently scored by a blind evaluator who was a certified Speech and Language Pathologist. Unfortunately the post-test TOWL for Child D was misplaced, therefore, comparisons were only made for three of the children.

Handwriting

Two of the three children demonstrated improvements in rating from the pre-test to post-test, while the third child demonstrated a deterioration. Child A's initial rating was 4, while he received a final rating of 3. Child B improved from a rating of 1 to a rating of 2, and Child C from a rating of 0 to 1.

Vocabulary

Unfortunately the quality of the work that the children produced was so low for the most part as to preclude any measurement of vocabulary. (A minimum of 50 words is needed in order for this component to be scored). Child B achieved

a score of 2 in vocabulary on his post-test. All other stories received a score of 0.

Thematic Maturity

There was considerable variance in the quality of the written language that was produced by the children. As was the case in handwriting, Child A demonstrated a decrease in scores from 2 to 1. Child B improved significantly, achieving a pre-test score of 3 and a post-test score of 11. Child C maintained a score of 1 throughout the two assessments.

Questionnaire

Teachers of each of the children completed a questionnaire prior to and following the study in which they rated the child's cursive writing at that particular time, in both quality and speed, in relation to the rest of the class.

Prior to the study, child A was rated as 1, much slower than his peers, on a 9-point Likert-type scale pertaining to speed of writing. He received the same rating on quality of writing, indicating that he was perceived as much poorer than his peers. On the post-study questionnaire, the teacher rated his speed as 2, and his quality as 4. She qualified

her response by stating that, when effort was not applied, his quality deteriorated to a 2.

Prior to the study, child B received a rating of 2 for speed of writing and a rating of 4 for quality of writing. On the post-study questionnaire, his scores improved to a rating of 3 for speed of writing, indicating that he was perceived as being somewhat slower than his peers, and a rating of 4 for quality of writing.

Child C received ratings of 1 for both speed and quality of writing prior to the study indicating that he was perceived as being much slower and much poorer (legibility) than his peers in writing ability. On the post-study questionnaire, these ratings improved to 3, somewhat slower and somewhat poorer than peers.

Child D's teacher perceived his writing as being only slightly weaker than his classmates prior to the study. She gave him a rating of 3.5 for speed of writing, and 5 for quality of writing, indicating that in this specific area, he was the same as his peers. On the post-study questionnaire, his rating in speed improved to a 4, while his quality rating remained at 5.

Summary

All children showed a decreasing trend in quality scores as the series progressed. There was a significant change in trend following intervention for some of the letter groups for all of the children. However, Child B was the only one to achieve statistical significance in quality scores when the test of ranks was applied. Speed scores showed a different pattern with a general increase following intervention. None of the four children achieved statistical significance following ranking.

Results of the TOWL varied with Child B demonstrating improvement in all of the three components measured. One of the other two who were administered the test demonstrated marginal improvement in the Handwriting component while Vocabulary on both of their samples could not be measured due to the poor quality of the samples themselves. Results of the questionnaire indicated that all four teachers perceived an improvement in speed of writing in the classroom following intervention, while three of the four stated that quality was better.

CHAPTER V: DISCUSSION, CONCLUSIONS, RECOMMENDATIONS

This study had its beginnings in the strong belief that more could be done in the school system for children experiencing sensorimotor difficulties, with resultant problems in written output. Since these children experience considerable difficulty integrating sensory input, it seemed only natural that remediation should focus on this particular component of the process.

A review of the literature strongly supported the close relationship between sensorimotor ability and handwriting. However, an examination of the literature dealing with the effectiveness of multisensory programmes yielded less conclusive results, both in the general population, and for children with learning disabilities. The study was, therefore, developed to assist in providing more conclusive information in this area, and to answer the specific question "What are the effects of a multisensory writing program, if any, on the cursive writing ability of children with sensorimotor difficulties?"

A single case with multiple baselines across behaviours design was used, with the behaviours being cursive writing

ability of five distinct letter groups. The five groups were taught in random order, one group every two weeks, in a one-hour session. Repeated measurements of writing speed and quality for each letter group were made. This design was repeated over three other cases.

Results of the study yielded statistical significance in trend changes in specific letter groups for all of the children. Only one child achieved statistical significance in the improvement in overall quality scores, while none of the children achieved statistical significance in speed scores.

The results of the study demonstrated considerable variation across the four children with regards to effectiveness of the cursive writing program. While it is impossible to identify a specific causal relationship, a number of factors could have influenced the eventual outcome.

The variation in results may have reflected the individual strengths and weaknesses of the children and their relationship to the method of intervention. Certainly, the four children entered the study with varying levels of ability. Child D was experiencing the least degree of difficulty with cursive writing within his school setting,

both in the quality of the formation of the letters, and the speed of output. Child C had only just learned the formation of the cursive letters, following years of struggle with written output, and was far from having established automatic "engrams" for the letters at the outset of the study. Child A and Child B demonstrated difficulties that were somewhere between these two extremes.

It was evident during the study that Child A and Child D had additional postural difficulties which affected how they sat, how they moved their arm across the page, and how they grasped their pencil. Since these difficulties were separate from the sensorimotor difficulties that they were experiencing, these could not be addressed by the researcher during the duration of the study. Equally it was not expected or intended that the multisensory program would have any spontaneous effect on these difficulties. Nonetheless, these were problems that would have an additional effect on their written output.

While three of the children had no difficulty attending for the full hour of therapy each session, Child A needed to be brought back to task on a number of occasions throughout the study. Similar difficulties were present in the classroom, and his teacher reported that his performance in this area

on any given day was dependent as much on attentional and motivational factors as on ability.

Factors such as the physical setting during administration of the trials, and the time of day and week during which the trials occurred may have also had varying effects on the different children. It was noted by the evaluators during the study that many trials had to be postponed due to professional development days, illness on the part of the student or the evaluator, and school events. In many instances, trials subsequently occurred on consecutive days, instead of the recommended three days a week, and in one or two instances, two trials were administered on the same day. Frequently, make-up trials were not administered, thus all but Child D finished the study with less than the full thirty-six trials.

In reviewing the pattern of scores for Child D, it was noted that, immediately prior to the intervention of some of the letter groups, there were two or three low scores, similar to the scores seen subsequent to the intervention. It is quite possible that a few trials were missed in the initial Series, and in her lack of understanding of the research design, the evaluator simply used the initial three trials of the next series to complete the initial Series. The

figures pertaining to Child D suggest that this pattern continued until the final Series, when the evaluator administered an additional three trials to complete the 36. The evaluator was unable to subsequently ascertain this, therefore the results for child D have been kept as six series, each comprising six trials. However, if changes in the timing of administration of trials did occur, both the trend changes for individual letter groups and the overall degree of change of quality and speed scores for Child D would have been affected.

A situation such as this could have been prevented by ensuring that all evaluators submitted the results of trials at the end of each of the series, and this would be a strong recommendation for further studies of this design.

All four children demonstrated statistically significant trend changes in quality scores of one or more letter groups following intervention; however, in only one of the four children was the change in each of the letter groups great enough to yield statistical significance overall. In each of the other three children, improvement that occurred in letter groups during their baseline phase was often great enough to mask the improvement in letter groups that had received intervention.

It is presumed that the spontaneous improvement that occurred during the baseline phase was due to learning on the part of the children. While efforts were made to control for this by using six different regimens on a rotational basis throughout the 36 trials, it would appear that with subsequent trials, an element of learning did occur. While it is not suggested that the children remembered the specific combinations of letters from series to series, they, no doubt became familiar with the general patterns.

As noted in a previous chapter, it is assumed that all four evaluators were consistent from session to session in their scoring system. However, it is quite possible that during the initial two or three trials, they were most careful in their perusal of the children's letter formation, with an increasing tendency to move quickly through the scoring procedure in subsequent trials, thereby missing some errors. This would be reflected in the results, and might further explain the "spontaneous improvement" in quality scores that the children exhibited during the study regardless of intervention.

It was noted during the study by all evaluators that while the criteria for quality points encompassed a number of errors in the formation of the letters, all four children

made errors that were not addressed in the criteria. While this would not necessarily contribute to the spontaneous decrease in scores during the baseline phase, it could mute all scores across all phases. Consequently, changes made according to the quality criteria might not truly reflect the extent of each child's improvement in performance.

The improvement that all four children demonstrated in speed scores during the baseline phase could, as in the case of the quality scores, be attributable to a learning effect. In this case, however, it is suspected that the learning was a function of familiarity with the procedure. Efforts were made to control for this by only timing the child from the moment he/she put his/her pencil onto the paper to produce the first letter of the combination to the moment he/she lifted his/her pencil after producing the last letter of the combination. In addition, the child was encouraged to look at and memorize the entire four-letter combination before beginning to produce the first letter. However, this may have been a skill that was not well-developed at the outset of this study, and one that improved with practice as the study progressed.

Of particular interest was the increasing trend in speed scores from the baseline phase to the intervention phase in

all four children. Since the literature indicates that multisensory writing programmes have implications for all facets of written work, it was thought that the speed score trends would generally mirror those of quality. It is quite possible that following the intervention of a letter group, the children concentrated on the quality of those particular letters to the detriment of the speed.

Another thought that may be developed from these patterns is that, unlike quality, speed is unlikely to show any immediate improvement following intervention. Instead, it will tend to improve over time. This thought is born out by the results of the questionnaires in which all four teachers perceived an improvement in speed of cursive writing from the beginning of the study to the end.

While it had been thought that the degree of compliance with regards to the homework would have a significant effect on the outcome, this was not the case. Child C and Child D were totally compliant with their homework, while Child A and Child B each completed homework for three of the five groups. An examination of the results of specific letter groups of these two children and their patterns of homework compliance yielded no correlation between the two variables.

Homework compliance is often found to be a significant factor in the effectiveness of intervention programmes. It may be, however, that the written work that the children completed within the school day provided the necessary carry-over, and masked the effects of the homework program.

In reviewing the results, it is perhaps just as valuable to determine those factors which may have contributed to the significant improvement in Child B as it is to discuss those factors which may have negatively affected the other students' progress. Child B had a moderate sensorimotor "impairment" with no additional motor control difficulties or attentional problems. He had an extremely supportive family and school environment. Perhaps, the most significant factor was his strong motivation to improve, which was perceived by the researcher as being considerably higher than that of the others.

Results of the TOWL were, for the most part, consistent with the findings relating to the hypotheses. Child B was the only child to demonstrate improvement in all domains measured. Child C's moderate change in only the Handwriting component reflected the small changes made in quality and speed scores on the trials following intervention. Child A's "deterioration" was very likely a function of his short

attention span and high degree of distractibility, already discussed as a possible factor affecting performance during the trials. As a highly distractible child, Child A was also at greatest risk to lose interest in the TOWL upon readministration.

The rationale for assessing the Vocabulary and Thematic Maturity components of the TOWL had been to determine whether written expression matures when the task of writing itself becomes easier. The results of Child B suggest that there may be a correlation. While caution must be maintained due to the limited results, the remarkable change in Child B's thematic maturity over the six-week period is quite significant.

It is interesting that the greatest changes that occurred in this study were the perceptions that each child's teacher had of his/her performance. While all teachers stated that difficulties with both the quality and speed of writing remained following the study, everyone was emphatic, both verbally, and in response to the questionnaire, that considerable improvement had occurred. (It should be noted that the teachers were not given their previous ratings when responding to the post-study questionnaire).

While quality and speed of cursive writing were the only two outcome measures examined in this study, it was interesting to note that two of the four teachers made reference to their students' increased self-confidence in writing following the intervention. While each child had been extremely unwilling to put pen to paper prior to the study, there was a very noticeable increase in enthusiasm following it.

The discrepancy between the teacher's perceptions and the results of the trials perhaps reinforce some of the weaknesses within the study itself, discussed in this section, which reduced the significance of the results themselves. While one cannot eliminate the possibility that the teacher was influenced in his/her rating by his/her knowledge of her student's participation in the study, she had the opportunity to observe her student's improvement in all letter groups and the overall effect of the intervention before making her judgement. In the case of speed, this may have been particularly relevant since, as previously suggested, this particular measure may improve over time.

Finally, the results of the study are particularly relevant, since they emphasize the success and effectiveness of the cursive writing program on a functional level. While

statistical significance was only achieved in one of the four children for quality, it can perhaps be stated that the results of this study achieved significance on a clinical level, at least in measures of quality.

Implications and Conclusions

As was discussed in the second chapter, the literature pertaining to the effectiveness of multisensory writing programmes in improving cursive writing ability in children with sensorimotor problems is somewhat inconclusive. This study was developed to investigate further the correlation between these two variables and to possibly provide some more conclusive findings.

The results suggest that there are effects; however, the extent and scope of these effects are still very much debatable. Variance in the results across the four cases in terms of changes in quality and speed scores prevents one from drawing any overall conclusions about the effectiveness of the program on these outcome measures within the confines of this study. However, the various factors discussed earlier in this section, which may have contributed to the variance and prevented greater improvements in scores in

some of the children, must be taken into consideration in the final evaluation.

All four children experienced statistically significant changes in trend lines for specific letter groups following intervention. In addition, one of the four children had overall results in quality score changes that yielded statistical significance. These results, while perhaps inconclusive when examined in conjunction with the rest of the data, certainly provide some evidence of the continued need for research with programmes of this nature.

The effect that this program had on the confidence that each child had in his/her own writing ability, while never examined specifically, was made very apparent in the responses from the teachers. The increase in self-confidence, while secondary to changes in speed and quality, nonetheless may have had just as great an impact on the overall improvement in performance in the classroom. Further research in this area is certainly warranted.

The significant improvement in Thematic Maturity scores on the TOWL for Child B suggest a correlation between improvement in handwriting skills and maturity of written expression. While the findings are limited, they may provide

some insight into the difficulties that children with sensorimotor problems experience with written language itself.

The most interesting findings are perhaps those relating to the perceptions that the teachers had of the changes that took place within the classroom. The degree of enthusiasm which was shown by the teachers towards the program as a result of the improvement in their students is reflected in the fact that two of the four teachers subsequently implemented the program themselves in their classrooms to improve the overall writing ability of all their students. The literature has shown that multisensory approaches can be very effective in the teaching of handwriting (Birch & Lefford, 1967; Furner, 1970; Sovik, 1976; Hayes, 1982). Perhaps variations of programmes such as this one can find their way into the curriculum as part of the teaching of cursive writing skills.

Recommendations

It has been determined that the multisensory writing program had a significant effect on the cursive writing ability of one of the four children in this study. However, the overall results of the program remain somewhat inconclusive. In

order to provide more answers to the question "What is the effect?", further research is warranted.

Randomized controlled studies would eliminate some of the variables that were present in this study; however, the need for large numbers of children, and the financial and time demands would make it a particularly difficult design to implement. It is recommended, instead, that similar single-case designs be used with changes implemented to control for some of the variables. These might include more rigorous screening of potential study subjects to control for additional and unrelated difficulties, a longer baseline phase to allow scores to stabilize following an initial expected "learning" period, stricter guidelines regarding time of administration of trials, and more indepth and continual orientation of evaluators to the scoring system. It is also recommended that a measure of speed be obtained subsequent to completion of the study and compared with measures of speed obtained prior to the study.

It is hoped that the results of this study will provide direction for further research into writing difficulties and remediation. While work has been done in delineating various forms of writing dysfunction (Malloy-Miller, 1985), further research is needed in achieving reliable measures that will

isolate writing difficulties due specifically to sensorimotor problems. Further development of evaluation tools that specifically assess the quality of the formation of cursive letters is also warranted.

Self-confidence was an area found by the teachers to have improved following the intervention. If this study is to be repeated in some capacity, it is recommended that this be included as an outcome measure. It was also noted in analyzing the results that one of the factors affecting the variance may have been the degree of severity of difficulties at the outset of the study. Continual single case designs, implementing the same program, can be used to draw some conclusions about the relationship between degree of severity and success of the program.

Lastly, while this study focused on children experiencing solely sensorimotor difficulties, the literature identifies certain neurodevelopmental disorders such as Spina Bifida which include handwriting difficulties relating specifically to sensorimotor problems (Ziviani, Hayes and Chant, 1990). Perhaps further research can focus on the remediation of writing skills in these distinct groups of children.

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APPENDIX A

LETTER OF EXPLANATION AND CONSENT

I, _____, consent to have my child participate in a study which will examine the effectiveness of a cursive writing program on my child's writing ability.

_____ , the principal investigator, has explained to me that my child will be given five one-hour sessions of writing remediation, with the sessions being conducted once every two weeks at school. Each session will aim at improving a particular group of letters through the use of pencil and paper activities, chalkboard and other media. The sessions will be conducted by the principal investigator herself.

I understand that during the two weeks immediately prior to the first session, a second person will assess the speed and quality of my child's writing ability in the different letter groups six times (three times a week for each of the two weeks). This pattern of testing will be repeated following each of the writing remediation sessions, with six final tests following the final session. I understand that each testing session will last approximately fifteen minutes.

I have been told that my child will be required to complete fifteen minutes of writing practice each evening during the duration of the study. I will record in a book provided by the investigator the amount of time spent on the work each day, and the nature of that work. The book and all completed homework will be taken to all remediation sessions.

It has been explained to me that all information that is collected about my child during the study will be kept confidential, and that, if the results are published, my child will not be identified in any way. I also understand that I may refuse to have my child participate or may withdraw him/her from the study at any time without affecting my child's care at this centre.

_____	_____	_____
Parent/Guardian	Signature	Date
_____	_____	_____
Witness	Signature	Date

I have explained the nature of the study to the child's parent/guardian and believe that he/she has understood it.

Name	Signature	Date

If you have further questions regarding the study, please contact Julia Lockhart at 521-2100 ext. 7031.

APPENDIX B

CHILD'S CONSENT FORM

I _____ agree to be in an experiment which looks at how well a special writing course will help my writing.

_____ has told me that I will spend five hours, one hour every two weeks, with her at school. We will do writing exercises. Each time we will work on a different group of letters, using different types of activities.

Before my first session with _____, another person will test my writing six times (three times a week for two weeks). The other person will do these tests again six times after each of my sessions with _____. Each test will take about fifteen minutes.

I will have to do fifteen minutes of writing practice each evening during the experiment. My mother or father will write down in a book how much time I have spent on the writing practice. They will also write down what exercises I have done. I will take the book and my homework to all my sessions with _____.

_____ will not show any of my work to anyone. I know that I can stop taking part in the experiment at any time.

_____	_____	_____
Child	Signature	Date
_____	_____	_____
Witness	Signature	Date

APPENDIX C

SAMPLE OF SESSION FORMAT

1.a) The child will trace two lines of four-inch joined letter 'c's on a blackboard, progressing to two-inch letter 'c's, the one-inch.

-provides proprioceptive (information received from receptors located in the joints, muscles and tendons) and visual information about correct letter formation
-requires increasing motor control with decrease in size

b) The child will copy a one-inch stimulus letter 'c', producing from one to four lines, depending on the need of the child. Copying will be augmented by verbal prompts, as needed.

-provides visual feedback about what the child has just produced
-provides auditory input to reinforce correct formation

c) The child will repeat a) and b) with the other letters of the group, in the following order: a, d, g, q and o.

d) With eyes closed, the child will produce the letters of group as they are named by the researcher.

-provides the child with kinesthetic (conscious awareness of movement) feedback about the letter that he has just produced

2. The child will trace a large letter 'c' on newsprint, over a rough surface, five times with a felt pen. This process will be repeated with all other letters of the group, using felt pens of different colours. All stimulus letters will be drawn over one another.

-provides proprioceptive and visual information about correct letter formation
-reinforces the similarities in initial formation of the letters in the group, while illustrating the differences in finish and follow-through

3.a) With eyes closed, the child will produce the letters of the group in rice, as they are named by the researcher.

-provides tactile information (information received from receptors located in the skin) about correct letter formation
-provides the child with kinesthetic feedback about the letter that he has just produced

b) The child will produce words containing letters of the group, in rice, as they are dictated by the researcher.

-provides tactile information about correct letter formation
-provides the child with kinesthetic and visual feedback about what he has just produced
-requires planning of formation of different letters in sequence

4. The child will copy the same words on newsprint, over a rough surface, approximately two inches in height.

-provides kinesthetic and visual feedback about what he has just produced
-requires moderate amount of motor control with pencil
-requires planning of formation of different letters in sequence

5. The child will complete an exercise sheet which will consist of tracing the letter 'c', the copying all letters of the group, with two rows of each letter, all letters of normal size.

-provides visual information about correct letter formation
-provides kinesthetic feedback about what has been produced
-requires significant motor control with pencil

APPENDIX D

SAMPLE OF LETTER COMBINATION SHEET

#1

qoqo	ocdd
ccqo	odqo
qdcq	dcca
qcaq	qoag
ooao	gdco

APPENDIX E

SCORE SHEET

#1

qoqo		ocdd		
f0000	___	0000	___	(x2)
s0000	___	0000	___	
e0000	___	0000	___	
c0000	___	0000	___	
a0000	___	0000	___	
d0000	___	0000	___	
ccqo		**odqo**		
f0000	___	0000	___	(x2)
s0000	___	0000	___	
e0000	___	0000	___	
c0000	___	0000	___	
a0000	___	0000	___	
d0000	___	0000	___	
qdcq		**dcca**		
f0000	___	0000	___	(x2)
s0000	___	0000	___	
e0000	___	0000	___	
c0000	___	0000	___	
a0000	___	0000	___	
d0000	___	0000	___	
qcaq		**qoag**		
f0000	___	0000	___	(x2)
s0000	___	0000	___	
e0000	___	0000	___	
c0000	___	0000	___	
a0000	___	0000	___	
d0000	___	0000	___	
ooao		**gdco**		
f0000	___	0000	___	(x2)
s0000	___	0000	___	
e0000	___	0000	___	
c0000	___	0000	___	
a0000	___	0000	___	
d0000	___	0000	___	

_____ _____

Total point score _____

Total time score _____

APPENDIX F

DIRECTIONS FOR ADMINISTERING TRIALS

Administer trials at approximately the same time each day, three days a week, preferably Mondays, Wednesdays and Fridays.

#1 words should be administered the first day, #2 words the second day, and so on. Once #6 has been completed, begin again with #1 words.

If the child is away on a trial day, make up the trial on the next available day.

Administer the letter groups in the following order:

c a d g q o
m n v x y z
e l h b k f
i j t u w
p r s

To administer, begin the stopwatch as the child puts the pencil down on the paper to produce the first letter of the first combination of four letters. (Letters should all be done in cursive writing). Stop the stopwatch when the child has finished the fourth and final letter of the combination, but do not take it back to zero. Start the stopwatch when the child starts the second combination and continue in this fashion until all 10 combinations of letters in the group have been completed. Record the total speed score in seconds in the allotted space at the bottom of the score sheet.

To score for quality of writing, proceed in the following way:

To score for formation (f), record in the appropriate bubble on the score sheet if the child forms the letter incorrectly eg. wrong direction in formation.

All other aspects of quality should be scored after the child has completed the trial.

To score for start (s), fill in the appropriate bubble if the child starts the letter in the wrong place.

To score for end (e), fill in the appropriate bubble if the child finishes the letter in the wrong place.

To score for closure (c), fill in the appropriate bubble if the child does not close the letter properly.

To score for ascenders (a), fill in the appropriate bubble if the ascender on the letter touches the top line or does not reach more than half way up between the two lines.

To score for descenders (d), fill in the appropriate bubble if the descender is more than 1/4 or more than 3/4 into the space between the two lines.

After all the appropriate bubbles have been filled in, add up each column, being sure to double the point value on each formation (f) line. Write the total point score on the appropriate line at the bottom of the score sheet.

A score sheet should be completed for all five groups of letters at each trial.

APPENDIX G

QUESTIONNAIRE

_____ is presently involved in a research study which is focusing specifically on cursive writing ability. To help us better assess his current level of ability, will you please take a few minutes to answer the following two questions, basing your answers on your observations of his writing skills over the past several weeks/months.

How would you rate this child's cursive writing ability in comparison to that of his/her peers, in terms of speed?

much slower than peers				the same as peers			much faster than peers	
1	2	3	4	5	6	7	8	9

How would you rate this child's cursive writing ability in comparison to that of his/her peers, in terms of legibility?

much poorer than peers				the same as peers			much better than peers	
1	2	3	4	5	6	7	8	9

Thank you for your time.

Julia Lockhart

QUESTIONNAIRE

_____ has just completed his involvement in a research study which has focused specifically on cursive writing ability. Prior to the study, you were asked to rate his writing skills in the areas of speed and legibility. Will you again please take a few minutes to answer the following two questions which pertain to his present writing skills, basing your answers on your observations of his performance over the past few days.

How would you rate this child's cursive writing ability in comparison to that of his/her peers, in terms of speed?

much slower than peers — the same as peers — much faster than peers

1 2 3 4 5 6 7 8 9

How would you rate this child's cursive writing ability in comparison to that of his/her peers, in terms of legibility?

much poorer than peers — the same as peers — much better than peers

1 2 3 4 5 6 7 8 9

Thank you for your time.

Julia Lockhart

APPENDIX H

PROCEDURE USED TO COMPUTE A TREND LINE

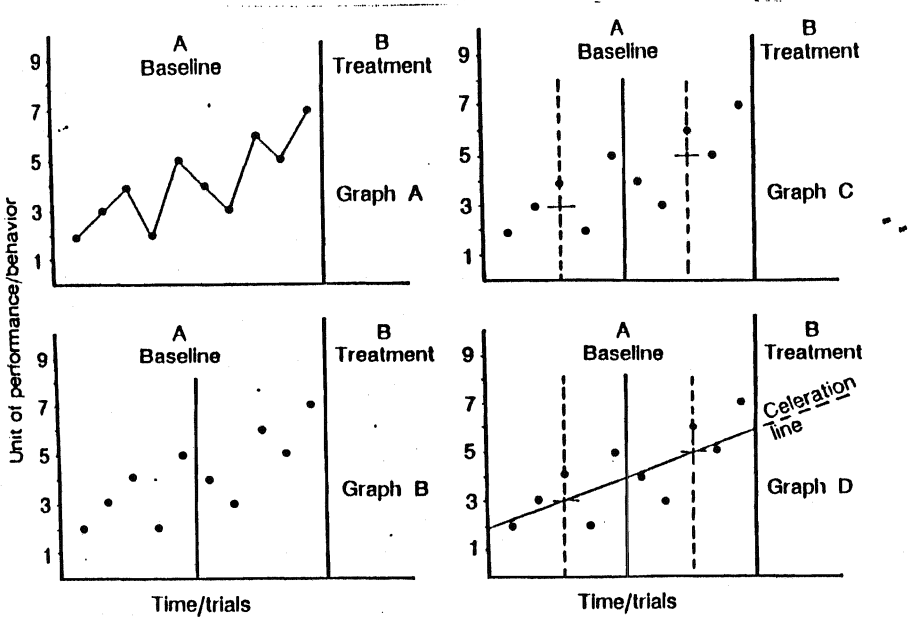


Figure 41. Steps involved in computing the trend line

Graph A is the original data series. In graph B, the baseline data series is divided in half. In graph C, each half of the baseline is divided in half again (dashed vertical lines), and the median values are marked on the dashed lines. In graph D, the trend line is drawn (Ottenbacher, 1986).

APPENDIX I

EXAMPLE OF A DATA TRANSFORMATION

Example: Quality Scores for Letter Group 2: Child D

For Child D, letter group 2 received treatment just prior to Series 6 (see Table 23). Using the equation

$$\frac{Bi-Ai}{Ai}$$

where Bi was the mean performance level for letter group i in the trial series immediately following treatment, and Ai was the mean performance across all baseline days (initial Series) for the same letter group, the mean values for Child D were substituted as follows:

$$\frac{17.00-28.67}{28.67}$$

$$= \frac{11.67}{28.67}$$

$$= -.41$$

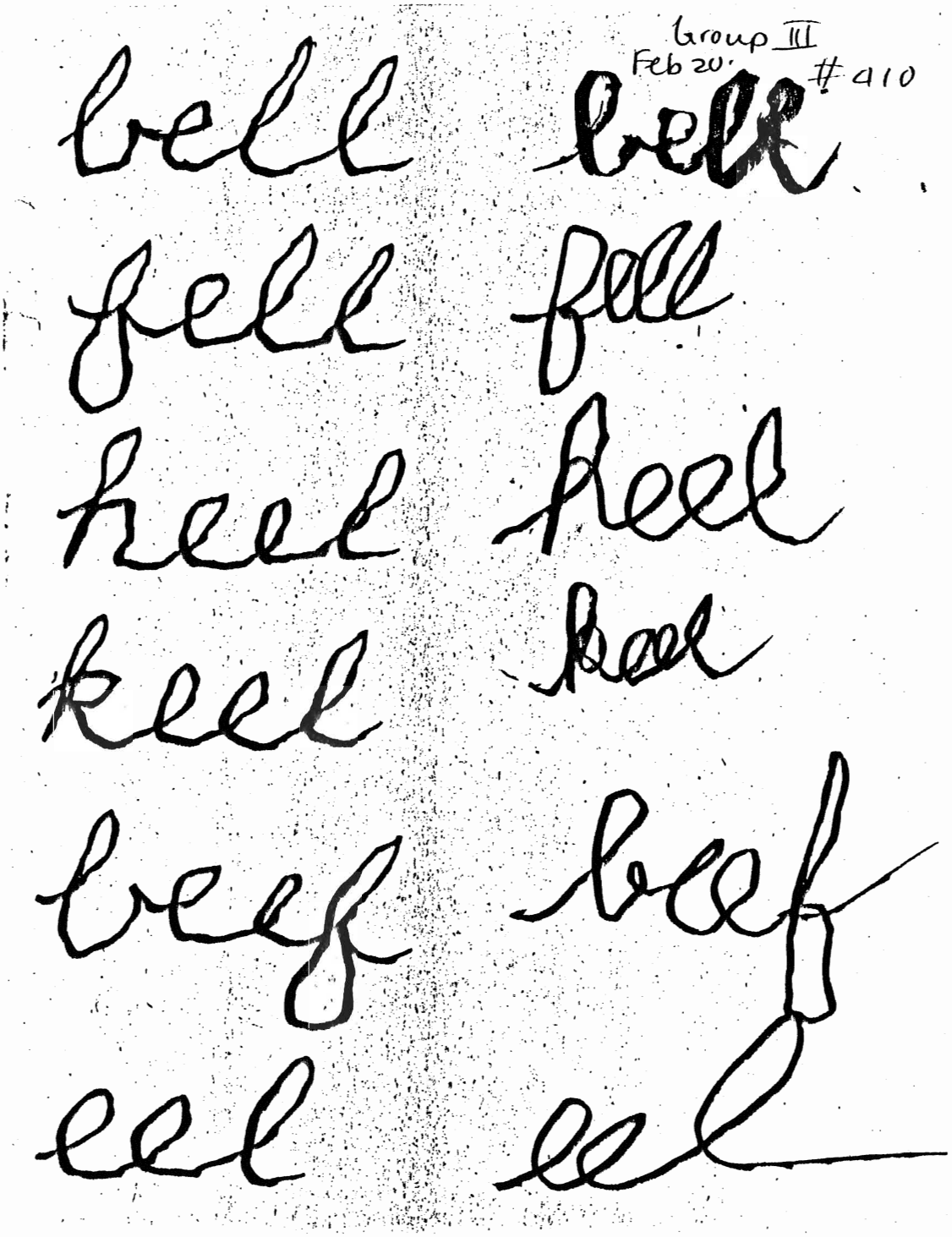
The final value for the mean of quality scores for letter group 2: Child D following the data transformation was -.41 (see Table 27).

APPENDIX J

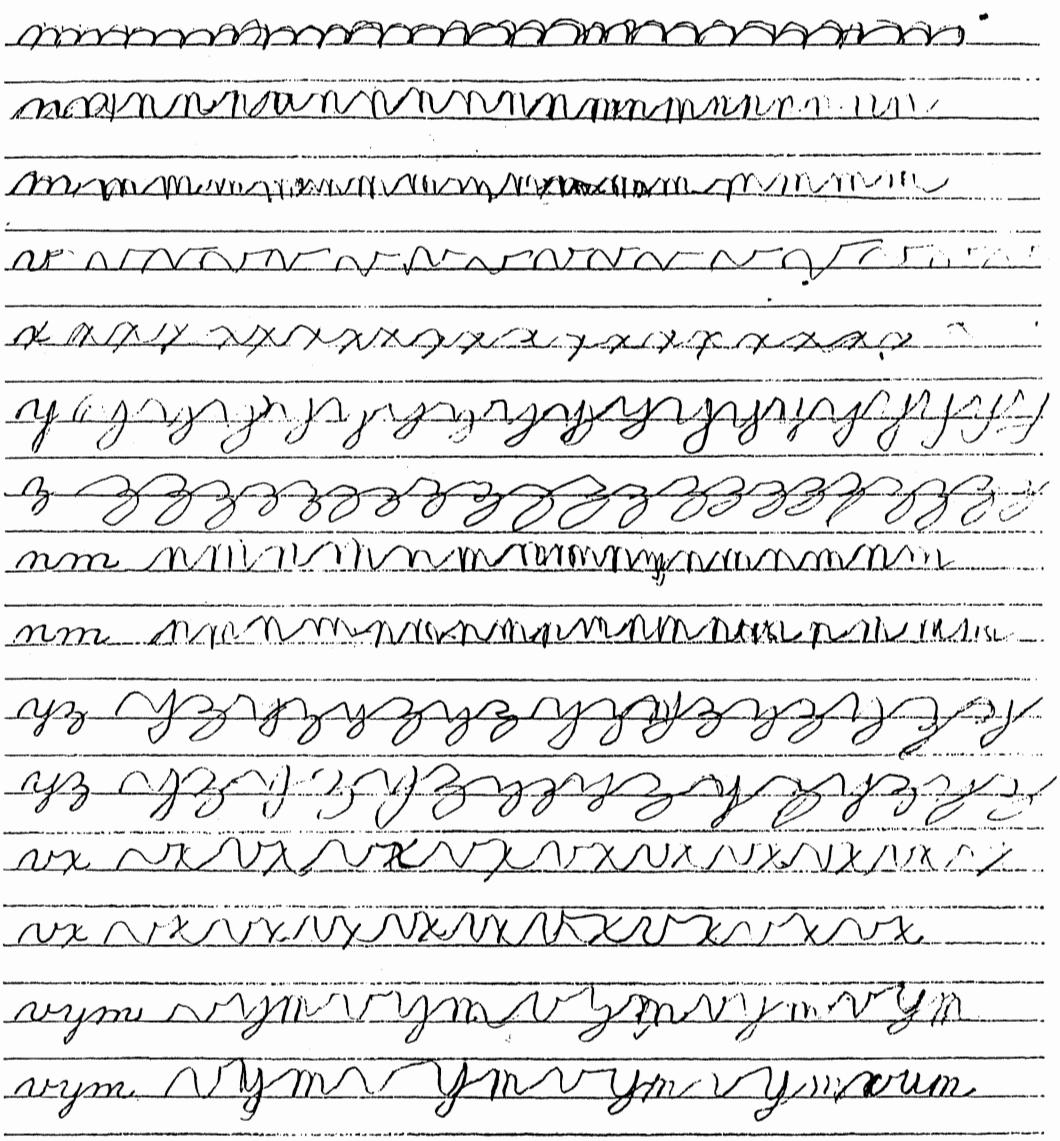
SAMPLES OF STUDENT WORK

Enlarged letters traced over a stimulus on newsprint, over a rough surface, five times each with a felt pen, a different colour for each letter.

Words produced on newsprint, over a rough surface, approximately two inches in height (sample is reduced).



Exercise sheet consisting of traced and copied letters (sample is reduced).



Child B: TOWL composition prior to intervention

#2

a Flaame went in a and
spsh to hakakmtc ansers
and mor ploplre came
and Phuldagoadm

Child B: TOWL composition following intervention

once there was a fomle
that lille on the Blak
Star and planit Star
las the clash to the
Sun and one day the
planit Staatid to
crake so the fiame
mouid to the planit
Sakoe. -opie the wiay
to cakoe the plant
Stae Leve up
thay mele lakey
to gate aut in
time thay lad at
Sago and mad
and foie and
ood one of the Lel
cod all the Stalle
a faue and Wat
houl it oame to
be.